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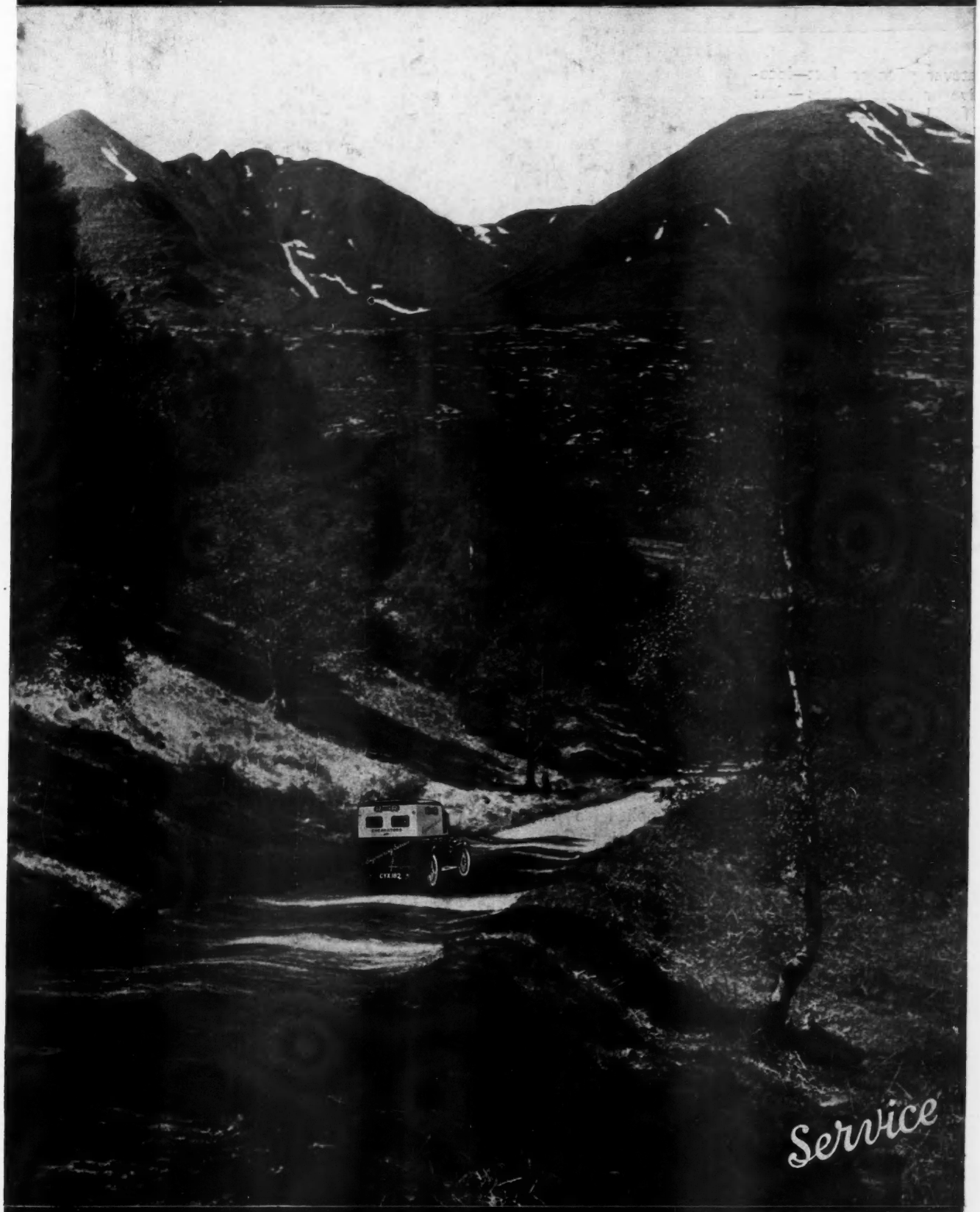

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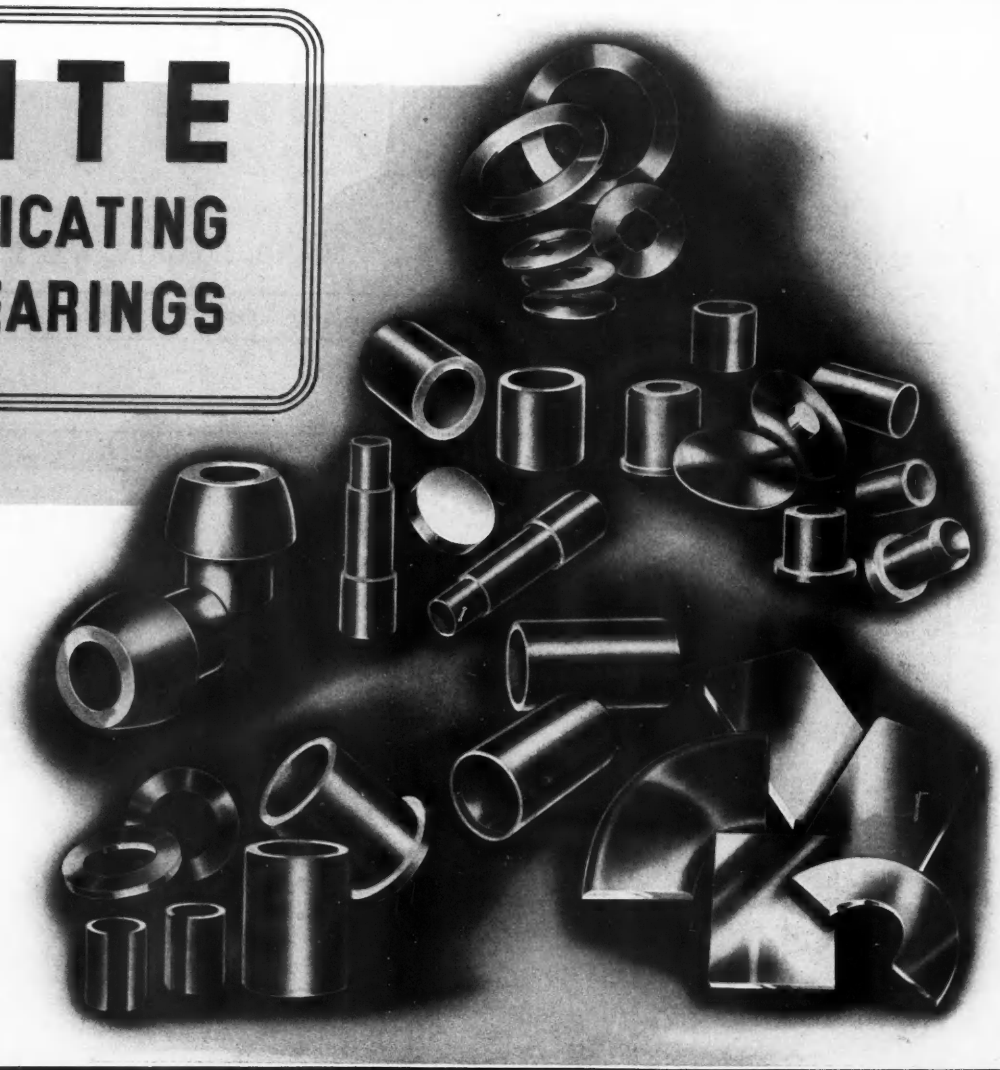

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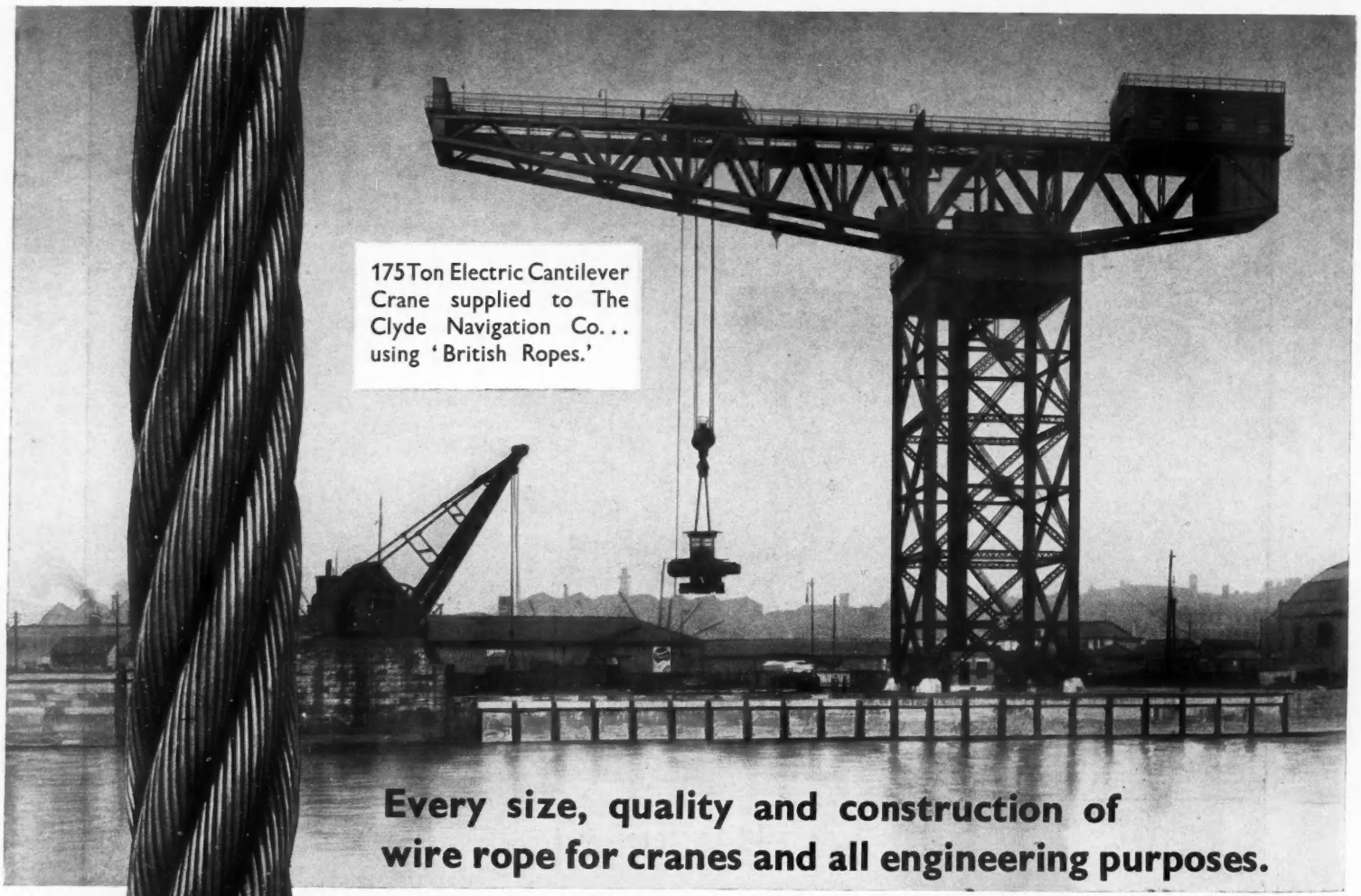

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A Seven-Day Journal

A Council of Supply

IN a review of the work of the Ministry of Supply, which was given by Mr. Leslie Burgin, the Minister of Supply, speaking in the House of Commons on Thursday, September 21st, it was stated that, following the precedent of the Ministry of Munitions in the last War, it had been decided to have a Supply Council of which he, Mr. Burgin, would be the chairman, and the Secretary of the Ministry, Sir Arthur Robinson, the deputy chairman. Engineer Vice-Admiral Sir Harold Brown would be Director-General of Munitions Production, and would continue to be responsible for guns, shells, instruments, machine tools, and ordnance factories, and the area organisations would be under his management. Lord Weir would be Director of Explosives, and would take over from Sir Harold Brown the responsibility for the production of explosives and chemicals. The production of tanks, mechanical transport, railway material, and engineering products, would be under the control of a third Director-General, and for this office Mr. Peter Bennett, the President of the Federation of British Industries, had been selected. Lord Woolton had been appointed the Director-General of Equipment and Stores, and the control of raw materials would be under the direction of Sir Andrew Duncan, the Steel Controller. Mr. Burgin then announced that Mr. Patrick Ashley Cooper, a Director of the Bank of England, had placed his experience at the disposal of the Council as Director-General of Finance. The responsibility for the military staff of the Department and its establishment would be in the hands of Lieutenant-General Sir Maurice Taylor, while the Parliamentary Secretary to the Ministry, Colonel Llewellin, would complete the Council, through which it was hoped to secure the maximum efficiency of working. He was able to state that Lord Weir, Lord Woolton, Sir Andrew Duncan, and Mr. Ashley Cooper had all asked to be allowed to serve without remuneration.

Organization of Supplies

DEALING with the organisation of supplies Mr. Leslie Burgin said that with regard to priority there were at the disposal of the supply organisation 9000 firms, most of whose plant had been critically surveyed, and which were provisionally allocated for the immediate production of war material, or were in a position to swing over to work on war material at an early date. There were directly working for the Ministry of Supply 6500 contractors, and their sub-contractors were country-wide. There was, in effect, a system of national factories, and whereas at the beginning of the defence programme there were only four Royal Ordnance factories there were now 28. In addition there were a very large number of factories, which although managed by firms, were in substance national factories, since the plant had been provided by the Government, and remained the property of the Government. The reason that a larger number of national factories had not been put in hand was that the time factor had been against it. He had great hopes that the area organisation which had been set up would make the best use of the smaller shops. The country had been divided into 13 districts in each of which there was a nucleus staff, with a trained and capable engineer in charge to deal with local difficulties which might arise in connection with transport, labour, and overlapping. The officers in these areas would have contact with the local divisional organisation of the Ministry of Labour and the other Ministries and industrial organisations. The expansion of the Army, Navy, and Air Force supplies had meant a great demand on our machine tool industries, Mr. Burgin went on to say, which was far greater than the industry could meet on a normal footing. There must, he said, be of necessity a considerable expansion of output in that section, together with purchases from overseas. While he could not go into details, he was satisfied that the machine tool industry was making an immense effort to supply the requirements of the Government.

The Control of Lighting

WE are given to understand that experiments are being carried out in London in order to test the possibility of effectively controlling the street lights of London by means of a central switch. It is hoped that if it should be possible to adopt such an automatic system, the Home Office would agree to the relaxation of the present total black-out, particularly at certain places which have been shown to be specially dangerous to pedestrians and traffic. While the authorities are desirous of safeguarding the safety of the public, it seems likely that the Home Office will not allow the relaxation of the present somewhat rigid and irksome rules unless it is possible to take the steps we have indicated without increasing the possible danger from attack from the air. Other matters which we understand are receiving the attention of the Home Office, are the standardising of appropriate lighting for trains and for road transport vehicles during black-out conditions. At the present time train lighting does not conform, we have noted, to any given standard, and in many cases there is a total absence of carriage lighting, or blue lamps are employed which give indifferent if any illumination. Such lighting besides proving an inconvenience to passengers increases, we learn, the difficulties of station staffs when operating trains at night time. The London Passenger Transport Board is also giving attention to the better lighting of buses, within the possible limits, especially with regard to the general lighting, with a view to assisting the conductor in the collecting of fares, and the making clearer of the numbers and the destination boards. The authorities are also studying the brightness of the automatic traffic lights which are used in all parts of the country. The penetrating character of the green light is receiving special attention, and in this connection the suggestion has been put forward that the present masks, revealing only a lighted cross, should be done away with, and the power of the lights lessened. It is possible that tests along these lines may be carried out.

Railway Wages

THE claims of the three railway unions for increased pay and better working conditions came before the Railway Staff National Tribunal, a meeting of which took place in London on Tuesday and Wednesday of last week, September 19th and 20th. Sir Arthur Salter presided, and other members of the Tribunal were Mr. H. J. May, who was selected by the unions, and Mr. H. E. Parkes, who was chosen by the companies. The assessors for the companies were Sir James Mills, Sir William Wood, and Mr. O. Cromwell, and for the unions, Mr. J. H. Potts, Mr. H. J. Evans, and Mr. W. Stott. The case for the National Union of Railwaymen was put by Mr. John Marchbank, the general secretary, and that of the Associated Society of Locomotive Engineers and Firemen by Mr. W. J. R. Squance, the general secretary, who referred particularly to the slow promotion of the men. It took more than ten years, he said, to graduate from the cleaning sheds to the footplate. He excluded from that statement the Great Western Railway, on which conditions were entirely different. The case for the Railway Clerks Association was argued by the general secretary, Mr. W. Stott. In his reply for the companies, Mr. Derbyshire pointed out that the outbreak of war made it impossible to offer up-to-date evidence about the railways' financial position. It was estimated, he said, that the cost of all the unions' claims to the companies would amount to £4,808,000 a year, while a 50s. minimum wage would alone cost £2,129,000. He declared that because of the cost, and the fact that traffic receipts had not fully recovered, the companies could not agree to the men's claims. At the close of the second day Mr. Derbyshire informed the tribunal that the recent increase in the minimum wage of 45*s.* a week represented the limit of concessions which the financial position justified. Even if it were possible to make further slight concessions, there was no hope, he held, in view of the present attitude, that the unions would be satisfied. He suggested that the unions must solve their differences and avoid presenting conflicting claims before their demands could be considered. The Tribunal adjourned on Wednesday and will consider its decision privately.

The Employment Returns

ON Friday evening, September 22nd, the Ministry of Information published a preliminary statement from the Ministry of Labour and National Service, with regard to the level of employment on Monday, September 11th. The outbreak of war, it says, created new demands for labour, but at the same time caused dislocation affecting the employment of workpeople in many directions. In the case of male workers, however, the net effect up to September 11th was a reduction of about 76,000 in the number registered as unemployed as compared with August 14th. The number of females on the registers was swollen by the addition of many evacuated women and of others offering their services, as well as by discharges from employment, and increased by about 175,000. Over the greater part of the country there was a reduction in unemployment among males and a roughly equivalent increase in the number of females on the registers. In London and the South-Eastern Counties there was an increase both among males and females. The industries mainly contributing to the increase in the numbers unemployed included hotel and boarding-house service, the distributive trades, the entertainments and sports industries, and the fishing trade. In some districts a decline in employment was also reported in some of the textile industries, motor car manufacture, and dock, etc., service. On the other hand, improvements in employment were reported in the coalmining industry, iron and steel manufacture, and the engineering and shipbuilding industries. The number of persons receiving assistance from the Unemployment Assistance Board under the permanent scheme on September 15th was about 375,000, or some 80,000 fewer than for the corresponding date in August. In addition, between 62,000 and 63,000 persons were being assisted by the Board under the emergency scheme for the relief of distress due to the war and of these about 46,000 were evacuated persons. The Ministry adds that, while the complete adjustment of industry to war conditions is bound to take some little time, it may be anticipated that any persons thrown out of work will soon find fresh opportunities for employment and that the increasing momentum of the national effort will call upon all the resources of our man-and woman-power.

A Tube Trade Merger

IN a Journal note of August 10th we recorded the merging of interests of Stewarts and Lloyds, Ltd., and the Stanton Ironworks Company, Ltd., by the purchase by Stewarts and Lloyds, Ltd., of the capital of the Stanton Company. At a meeting of Stewarts and Lloyds, Ltd., which was held on Friday, September 21st, the acquisition of the Stanton Ironworks Company capital was agreed to and resolutions were passed increasing the capital of Stewarts and Lloyds and authorising the directors to carry out the terms of agreement. In recommending the purchase and the passing of the resolutions Mr. A. C. Macdiarmid, the Chairman of Stewarts and Lloyds, Ltd., said that the results of the first eight months of the year were better than those of 1938. Outlining the policy of the company, Mr. Macdiarmid said that starting from the assumption that we must prepare for a war that might endure for a period of three years, the policy of the company was on one hand to hold its whole resources, potentialities, and skill at the disposal of the Government for the successful prosecution of the war, and on the other hand to do its utmost to preserve, throughout the difficult times ahead of us, the fabric of the company, so that when peace came it might emerge strong in resources and ready and able to deal with the conditions which would then arise. That, he said, was the policy which he trusted would have the full support of the shareholders. He added that the Board firmly believed that combined with Stanton it would be in a stronger position to carry out the policy which he had outlined. Mr. Macdiarmid added that it was of interest to record that the agreement had been ratified by over 90 per cent. of the holders of the ordinary stock and by over 90 per cent. of the preference stock of the Stanton Company. The resolutions were submitted to the various classes of stockholders at separate meetings and at the close of the extraordinary general meeting of the company, and in all cases they were passed unanimously.

Director-General of Transportation

IT is announced by the War Office that Mr. G. S. Szlumper, C.B.E., M. Inst. C.E., the general manager of the Southern Railway Company, has been appointed Director-General of Transportation and Movements at the War Office. He will be responsible under the Quarter-Master-General to the Forces for the general supervision of all military transportation requirements oversea, for the provision of the necessary plant and material, and for the arrangement of all military movements by land and sea. He will also under the Quarter-Master-General be responsible in conjunction with the Adjutant-General for the provision of transport personnel. Mr. Szlumper was trained as a civil engineer on the London and South Western Railway, and during the Great War was secretary of the Railway Executive Committee. After the war he served for some years as the Docks and Marine Manager of the Southern Railway Company. In 1926 he became Assistant General Manager, and in 1937 succeeded Sir Herbert Walker as General Manager. This year he is President of the Institute of Transport. Before his War Office appointment Mr. Szlumper was as General Manager of the Southern Railway Company a member of the Railway Executive Committee. It is announced that the Minister of Transport has appointed Mr. E. J. Missenden as a member of the Railway Executive Committee to replace Mr. Szlumper, and the directors of the Southern Railway Company announce that as from Monday, September 25th, they have appointed him General Manager and Traffic Manager. Mr. J. B. Elliot, Assistant General Manager, has been appointed to act as Deputy General Manager. In announcing these new appointments the Board states that it is happy to think that in times of national need its chief executives should be called on to assume the highest responsibilities.

Scottish Locomotive Experiences

By E. H. LIVESAY

No. II.—L.N.E.R., THE WEST HIGHLAND MALLAIG TRAINS

(*Continued from page* 234, *Sept.* 1*st*)

SURELY in the whole of Great Britain there can be no wilder or more rugged piece of country than West Scotland. One has only to look at the map and notice the jagged coast, the contorted rivers, the profusion of lochs and mountains, to see that Nature must have been busy for countless ages with her tremendous, never idle tools—sea, wind, and rain—fashioning this wonderful piece of sculpture, and that she is even yet working at it. An engineer who blazes a railway trail through such a wilderness of rock and torrent knows that, in spite of the best he can do, it must inevitably be a hard one for locomotives to follow. Curvature must be frequent, gradients sudden and severe, and climatic vagaries extreme. Only engines specially built to suit these conditions can give a really good account of themselves, and cope with the demands made upon them. Their work is sure to be exacting and strenuous. This conception is particularly true of the West Highland line between Glasgow and Mallaig, and for this reason I looked forward to travelling over it on the footplate, as it was to be the first of the routes in Scotland on which I hoped to continue the locomotive observations I have been recording, and which have been given in THE ENGINEER. I was all the more interested in this particular field, as I imagined it must be something like British Columbia, where my own trail began, and that I should feel at home in such more or less familiar surroundings. It all turned out just as I had anticipated. The engines were of a type I had not previously made acquaintance with, and their work proved hard and well worth looking into. Everybody, without exception, was friendly and helpful, the scenery was magnificent, and the weather beastly.

Following my usual plan, I will touch briefly on the civil engineering part of the story first. The starting point of the Mallaig route is at Queen Street Station, Glasgow, and it runs through Craigendoran Junction, to which place it is double track, Crianlarich, Rannoch, into Fort William, 122 miles. Coming out again from there, it carries on through the wildest country of the whole journey to the Mallaig terminus, 164 miles from Glasgow, the sum making the heaviest piece of railway construction that my experiences in this country have taken me over. Curves, gradients, speed restrictions, and stations alternate incessantly—sometimes they coincide. The difficulties of the locomotive work are intensified by fairly light permanent way and bridge construction, so altogether the engines have a hard task satisfying all these conditions, and the enginemen have just as trying a duty. It is certainly a line that has to be known thoroughly before the crews can do justice to it, and get the best work out of their machines. A driver with a tendency to day-dreaming would soon find himself on the carpet for losing too much time, or failing to observe speed restrictions; he might even find himself at the bottom of an embankment. A fireman with a weak back, too, would be better suited away from the Glasgow–Mallaig service; as an American might say, it is a he-man's proposition.

A route with such a saw-tooth profile is too difficult to describe in advance, so I think it would be best to do as the engines do—deal with its striking features as we come to them, meanwhile directing the reader's attention to the locomotives themselves.

It is clear that it could have been no simple matter to build an engine capable of fulfilling the demands of such a difficult line as the West Highland. A good many definite conditions have to be met. The sharpness of the curves calls for a short wheel base, and as a speed of 60 m.p.h. must be within the engine's compass, some kind of leading truck is necessary; 300-ton loads have to be hauled, and the allowable axle loading being limited to 20 tons, six coupled wheels become essential, of a size suited to the speed mentioned. Good acceleration is another vital point, the number of stops and considerable in-between speed making this requisite. Therefore the wheels must not be too big. From Glasgow to Craigendoran Junction, where single track begins, through trains have to keep out of the way of the local traffic, and it is over this stretch that rapid pick-up and a 60 m.p.h. maximum are called for; north of Craigendoran Junction speed is limited to 40 m.p.h., but this easement is offset by the severity of the gradients, which have to be experienced on the engine, or studied from a profile, to be appreciated.

It was considered that three cylinders would meet these conditions better than two, because of the resulting even torque tending to the reduction of slipping, and a large cylinder capacity to quick get-away. The outcome was the three-cylinder, 2–6–0 "K 4" class, which does most of the heaviest work between Glasgow and Fort William. The "K 2" "Loch" class, which preceded the "K 4," and is very similar in external appearance, has only two cylinders. It is also employed on the West Highland line, but was not designed specifically for it. It was a development of Sir Nigel Gresley's first 2–6–0 design. The "K 4" class, on the other hand, was built definitely to meet West Highland demands, to which it is well suited. I travelled on both these classes, and their performances will be dealt with in detail. Their leading dimensions are given below:—

	"K 2" class.	"K 4" class.
Cylinders, in.	(2) 20×26	(3) 18½×26
Valves:		
Diameter, in.	10	8
Maximum travel, in.	5⅝	5¾
Admission lap, in.	1¼	1¼, outside cylinders; 1⅜, inside cylinder
Exhaust lap, in.	1/16	nil
Cut-off, maximum, per cent.	75	65
Wheels:		
Coupled, diameter	5ft. 8in.	5ft. 2in.
Leading truck, diameter	3ft. 2in.	3ft. 2in.
Boiler, between tube plates	5ft. 6in.×11ft. 11⅞in.	5ft. 6in.×11ft. 7⅛in.
Heating surface:		
Evaporative, sq. ft.	1,629·5	1,421·6
Superheater, sq. ft.	305	310
Total, sq. ft.	1,934·5	1,731·6
Pressure, lb./sq. in.	180	200
Fire-box grate area, sq. ft.	24	27·5
Weight:		
On coupled wheels	53 t. 18 c.	57 t. 18 c.
On truck	10 t. 10 c.	10 t. 10 c.
On engine and tender	107 t. 10 c.	112 t. 12 c.
Tractive effort at 85 per cent., lb.	23,400	36,598
Adhesion factor	5·11	3·54
Coal, tons	6·5	5·5
Water, gallons	3,500	3,500

From these figures it will be seen that the tractive power is considerable, particularly of the "K 4" class, bearing in mind the moderate weight, and that the cylinder capacity is large in relation to boiler power. The requirements outlined above—rapid acceleration, &c.—explain this, and as long runs at high speed are not called for, no very extended calls are likely to be made for heavy steam production under these circumstances.

Arrangements in the cab are good, as I have always noticed on modern L.N.E.R. engines. A Flaman recorder was installed on all the "K 4" engines I rode. The speed-indicating part is always in operation, but recordings are only taken when desired. It is placed in front of the fireman's seat, where it can be easily seen; it is driven from the right-hand rear coupling-rod pin by a return crank. It is a very interesting device, and I shall have a good deal to say about it, not only in this article, but subsequently when more space is available. The cab gives good weather protection, a valuable asset on any engine working in these northern latitudes, where wind and rain are at least as common as blue skies and sunshine, and blizzards have to be faced in winter. The seats—King Charles's head bothered Mr. Dick no more persistently than these things do me!—are an improvement on the wooden shelves that so depress me whenever I look at them, and still more when I sit on them. The idea must have come from a snack bar; they are replicas of the round, revolving padded stools one sees there. That sight-saving, wind-deflecting strip of glass at the cab side is fitted to the window edge; it is a humane detail which should be found on every engine. On the "K 4s" the regulator handle is of the hanging type that I like so much; on the "K 2s" it is of the old Great Northern pull-out pattern. A steam-chest gauge, an informative guide to economical running that I like watching, is also standard, and there are two injectors, one live, and the other exhaust steam, the latter naturally doing most of the boiler filling, with the other as an auxiliary stand-by.

My first run was with the 5.50 a.m. train out of Glasgow for Mallaig, the load being about 275 tons gross, and the engine "No. 3445," "MacCailin Mór," with Driver Wilson and Fireman Patterson.

Immediately on clearing Queen Street Station the engine enters a tunnel, and simultaneously begins to mount the Cowlairs incline, a mile long 1 in 42 bank on which, in the old days, rope haulage was employed. The present method is to utilise full regulator and valve travel on the train engine, with a "pusher" at the rear, which has brought the train into the station. The strenuous pulling of "MacCailin Mór" quite nullified my work on the front window, which I had cleaned before we started. The vigorous exhaust fetched down pecks of soot off the tunnel roof, a good part of it sticking on the glass. (*N.B.*—wipers are sure to come into general use sooner or later; why not now?) There was no slipping, though there probably would have been but for the assistance of the pusher; tunnels are wretched things to get away through, especially when they are complicated by a 1 in 42 gradient. The regulator was full open, and cut-off 25 per cent.; more of the latter would, I suppose, have only been possible at the expense of adhesion. The weather was wet, with a strong wind, and I guessed that my hopes of enjoying the fine West Highland scenery under favourable conditions were going to be disappointed. Cowlairs Station is at the top of the incline, and here the pusher came off; it is an important junction, and the old N.B.R. Works, now only used for repairs, are close by. The line then runs through the suburbs, where local traffic is heavy and stations frequent. It is a manufacturing and shipbuilding district; at Dalmuir I caught sight of the "Queen Elizabeth" taking shape. The riding of "No. 3445" was good, better than I had looked for from a 2–6–0 with small wheels, which were turning over fast, the speed after Dumbarton, along the level shore of the Firth of Clyde, being over 50 m.p.h. It had been raining hard at the start, and I was glad of the good cab protection, but the weather is apt to change quickly in Scotland, and when we came to a stand in Upper Helensburgh at 6.33 a.m., the rain had stopped. Here the double track had been exchanged for single, and tablet-taking became necessary. It is carried on a loop, which slips over the extended arm of the catcher, the fireman having the duty so far as the engine crew is concerned.

At Craigendoran Junction the gradients begin in earnest. The ball opens with 1 in 58; there are innumerable examples of two-figure climbs on the West Highland; three-figure ones are no more common. On this, full regulator was used, with 15 per cent. cut-off, and the speed was 20 m.p.h. The climb ends near Rhu, where the rock cuttings, fir trees, and gorse brought Victoria, B.C., into my mind. The railway runs high above Gareloch here, the mist-shrouded mountains and great sheet of water making a good imitation of Lake Sicamous, on the C.P.R. main line, the similarity becoming stronger still on the 7-mile climb to Glen Douglas. Some of this is at 1 in 54, and the speed again came down to 20 m.p.h., as the train wound round the curves, hundreds of feet above Loch Long. Speed restrictions are very frequent on the route to Mallaig, not only the "blanket" one of 40 m.p.h., which covers the whole line north of Craigendoran Junction, but special restrictions for the numerous curves.

After Glen Douglas, there are 12·5 miles of downhill running to Ardlui, but it is seldom possible to utilise descents for the purpose of making up time, owing to the limits imposed everywhere. For instance, we were 3 min. late at Arrochar, on the way down, but they could not be regained, as there was a 30 m.p.h. restriction extending for 4·5 miles, plus a 20 m.p.h. slack for permanent way repairs, on this little piece. And so it was generally the case; if time was lost it remained so—impossible to pick up.

At Ardlui, a very heavy climb of 8 miles begins, most of it in the 60s, to Crianlarich, reached at 7.46 a.m., 5 min. late; 36 miles of very difficult single line had been covered in 77 min., an average speed of 28 m.p.h., with three stops. It does not sound much if you say it quickly, but it is really very good under the circumstances. And anyway, what do a few lost minutes matter, with such wonderful scenery to look at? Near Ardlui, the line runs through cuttings and thickets of pines,

high up, with 3000ft. Ben Lomond brooding over the placid, island-studded waters of the loch. I could not keep my attention inside the cab for long; it would stray "over the hills and far away" to the lochs, the torrents, and snow-tipped Bens. It was sometimes hard to realise that I was not back in British Columbia, and actually in Scotland, the land of romance I had always wanted to see so much. But the truth was brought home to me beyond a peradventure at Crianlarich, where I was charged 6d. for a cup of tea.

After Crianlarich we began to climb again, passing through drifting clouds at Tyndrum, out into sunshine, and on to the summit, 1024ft., then down by a steep 1 in 55 drop, round the "horseshoe bend," and still down to a stop at the Bridge of Orchy, 8.19 a.m., 71 miles from Glasgow; average speed 28·5 m.p.h. The elusive minutes had not been picked up yet, and the train was still a little late. But nothing seemed to matter up there. The engine, crew, and scenery—everything pleased me so much; even the steam chest gauge, which practically coincided with the boiler pressure gauge whenever the regulator was full, or nearly full open. Evidently there was nothing much the matter with "MacCailin Mór's" front end. This seems rather a disrespectful remark to make about a dignified Highland Chief; casual perhaps, but then the whole environment was full of chance-medley and contrast. It seemed quite natural to be absorbed in the majesty of "Ben Doran's" 3500ft. sovereign might at one moment, and turn to ask what the cut-off was the next.

At Bridge of Orchy a heavy 9-mile climb to Gorton begins, including 2 miles of 1 in 66. There was a "p.w.s." to 20 m.p.h. at "Bridge 179." One is seldom free of restrictions for some reason or other on the West Highland, but once over the top, a descent begins to Rannoch, which takes its name from the wild moor that spreads its expanse of heather, rock, and bog far and wide, over which the cloud shadows were chasing each other, the sun having by this time come out. Deer grazed quietly close to the line, not even looking up as the train went by. There is a snow-shed at Rannoch, and fences, mute testimony to the severity of winter storms that come upon this bleak wilderness out of the north.

Rannoch is at the foot of an 8-mile climb, the first part 1 in 53; it continues to Corrour, the summit of the West Highland line, 1350ft., after which it is 29 miles downhill to Fort William. The Spean boils alongside in its jagged cleft, like a miniature Kicking Horse River. Roy Bridge was left at 9.32 a.m., only 3 min. late, and, with Ben Nevis towering in the background, the track continues towards Spean Bridge. The air is like champagne up here; truly one is "clear of the stinks and sounds of town"—that is, if one shuts one's nose to the aroma from a distillery that lends a little local colour to the outlook. The twin water pipes of the great aluminium works cut their parallel lines down the mountain side, and Fort William was reached, still 3 min. late, at 9.57 a.m. The average speed over the 122 miles from Glasgow has been 29·6 m.p.h., very good indeed for this exceedingly heavy piece of line, with the by no means negligible 275-ton load.

The engine and its work pleased me very much. It steamed freely, the fireman having no great difficulty in keeping the needle near blowing-off point. It rode well, the incessant curvature being taken quite steadily, and with little objection; acceleration was good, and there was no doubt as to its ability to climb. I noticed, perhaps, a little more slipping than I was prepared for, but on looking up the factor of adhesion, and finding it to be 3·54, the mystery was probably solved. The cylinder horse-power is considerable, when associated with the 58-ton weight on the coupled wheels, but it gives the rapid pick-up that is asked for.

The train, reduced to 175 tons, left Fort William at 10.16 a.m., 9 min. late, headed by a 0–6–0 goods engine, "No. 9507," and the weather was again bad, raining hard and blowing strongly. It was of an old class, with two inside cylinders, and 5ft. driving wheels. Its riding was quite good, but as it was not of very recent build, it naturally lacked many refinements to be found on more modern machines. There were no deflectors at the cab-side, and as we were heading into half a gale I missed them considerably. Steam came down over the windows seriously—it smelt and looked like washing-day. The seat—shelf, rather, as it projected its stark simplicity into the cab unrelieved by a cushion—was narrow, and too close to the side. I was constantly in danger of being shaken off and shovelled into the fire-box. The reverse lever was of the old type, working in a notched quadrant, and only live steam injectors were fitted.

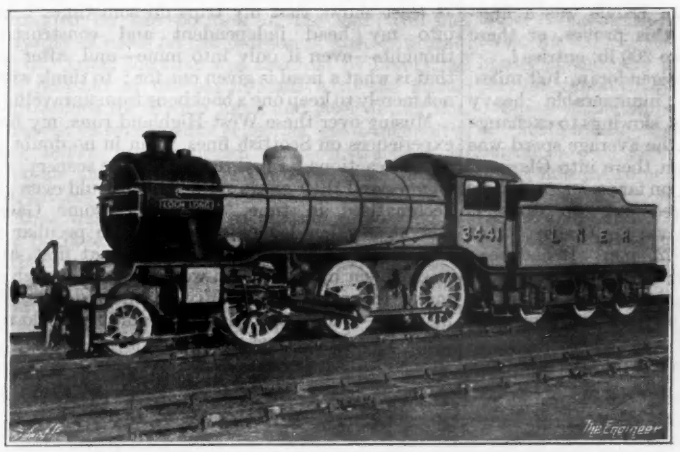
It is an outstandingly harsh piece of country between Fort William and Mallaig, a wilderness of rocks, lochs, and rivers. The gradients and tunnels are incessant, many of the former being in the 50s, and some even worse. At Glenfinnan the line crosses a fine stone viaduct nearly ¼ mile long and 110ft. high, and at Beasdale, a little way on, there is a gradient of 1 in 48, partly through tunnels to make things harder, in one of which "No. 9507" had a very trying time. The speed came down, down, owing to the heavy gradient and wet rails, and in spite of sand, slipping began, becoming so serious and persistent that I was really apprehensive lest stalling should be our fate. But the engine clawed her way to the summit at little more than walking speed. I have never felt a greater sense of relief at the mastery of difficulties by any engine I have been on than when we passed over the peak and began to run down to Arisaig. Driver Alliston and Fireman R. Macdonald—especially the latter—had all my sympathy. The narrow deep fire-box wanted heavy and skilful firing, and the hardest of work to keep the pressure up to concert pitch. The veteran gave a creditable performance. Notwithstanding a late start from Fort William of 9 min., 4 min. were made up despite the difficulties on inclines, and the arrival at Mallaig was only 5 min. behind time, at 11.50 a.m.

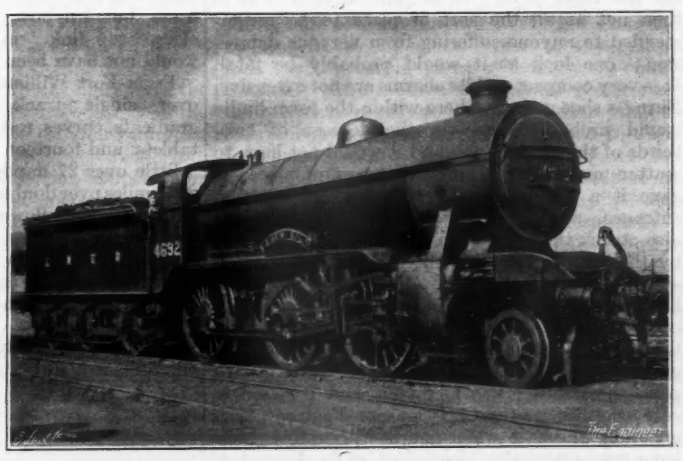
My turn around at Mallaig was quick. I left again at 12.10 p.m., 5 min. late, on "No. 4699," "Loch Laidon," 2–6–0, a two-cylinder "K 2" class engine, Driver Ness and Fireman E. Macdonald. These machines have right-hand drive, and I noticed at once that the working was harsher than that of the three-cylindered "K 4s." Beyond Arisaig, on a pitch of 1 in 45, the cut-off was 45 per cent., and the speed came down to 15 m.p.h., the load being 150 tons. Gradients gave no such trouble as had been the case with the other engine, and Fort William was reached at 1.46 p.m. I left again for Glasgow on "No. 3442" "The Great Marquess," a "K 4," with Driver Allen and Fireman Ralston, the load being still about 150 tons. I shall say very little about this run, as a few days later I repeated it on an engine fitted with a Flaman recorder, making the journey more graphic than can be the case without it. The weather was filthy, with wind, rain, and mist. The 40 m.p.h. limit was reached many times, and a late start of 10 min. was practically made up by Craigendoran Junction, where the double track begins. It was a fine piece of engine work, because, as I have said, it does not seem likely that lost time can often be made up on this line. The light load may have made it possible on this occasion. Over the double track, in the absence there of a multiplicity of curves and gradients, 20 miles additional speed are allowed, and at Dumbarton it went up to 55 m.p.h., making the riding somewhat rough, the working more obvious, and a knock on the right-hand side obtrusive; 5ft. 2in. wheels are apt to register some protest at 55–60 m.p.h., even though they may reach it fairly satisfactorily. All arrears were cancelled by the time Cowlairs was reached, but a lengthy signal stop outside the tunnel undid things again, the train coming to a stand in Queen Street Station, 3 min. late, at 5.45 p.m.

The weather having been so bad during the first Mallaig journey, arrangements were made for me to do it again, in the hope that conditions then would be better. I may say at once that they turned out, if anything, worse. I was to have the additional assistance of a Flaman recorder in full operation, so I naturally looked forward to a day free from drawbacks. But the "best laid schemes of mice and men, gang aft agley." Jupiter Pluvius was still working hard when I entered the cab of "No. 3444," "Lord of the Isles," another "K 4," Driver Adams and Fireman Dunn, and the train left Queen Street Station with a 165-ton gross load to attack the 1 in 42 climb through the tunnel to Cowlairs. Here we were held up, it seemed interminably, waiting for the addition of three coaches from the connecting Edinburgh train, which was very late. Such was the hurry with which we finally got away that there was no time to insert the paper reel into the Flaman, a thing that can only be done when the engine is stationary. This was another disappointment, as Crianlarich was the first stop sufficiently lengthy to allow of it being done, so it was decided to do without this valuable record on the northward run. The start from Cowlairs, with the load up to 275 tons, was at 6.18 a.m., over 20 min. late, which completely wrecked time-keeping right through to Fort William, and ultimately to the finish.

"No. 3444" made every effort to get back nearer to schedule time, but it was impossible, the load being heavy and the timing "tight." Along the double track to Craigendoran Junction, the speed reached 40 m.p.h. at Possilpark, 50 at Drumchapel and Dalmuir, and 60—the limit, the only time I noticed it on any of the runs—at Bowling. Dumbarton was passed slow, due to a signal check, at 6.37, 19 min. for the 14 miles from Cowlairs, an average of 44 m.p.h. At Cardross, 4 miles farther, the speed was up to 50 again, a signal stop then bringing us to rest at Craigendoran at 6.49 a.m. There was considerable slipping at the restart, Adams being evidently concerned at the late running, and a little over anxious to get away as quickly as possible.

It is very seldom that I have had to note even minor mechanical troubles on these runs, but one cropped up here; the exhaust steam injector began watering the track instead of the boiler. The cock between engine and tender was responsible and was soon adjusted. Whistlefield, 1 in 54, was taken at 20 m.p.h., and Ardlui, at the foot of the long 15-mile climb through Crianlarich—where a 7-min. stop was made for water—and





L.N.E.R LOCOMOTIVES OF THE K4 AND K2 CLASSES

Tyndrum, found the train still 17 min. late. Slipping occurred once or twice, the speed coming down to 25 m.p.h. My withers were wrung near here by a ewe and her lamb gambolling along the track in front, between the rails, only my frenzied but silent prayers getting them clear in literally "two shakes of a lamb's tail." If our locomotive Juggernaut had crushed them my day would have been completely spoilt.

Between Bridge of Orchy and Corrour there is a heavy pull, with a long 30 m.p.h. restriction round a succession of bends, and I seized the opportunity to breakfast in the dining car, the attendant politely declining to spread newspapers over the cloth, saying it was not necessary. It was, as by this time I was in my usual state of filth. I cannot explain why I always get very much more dirty then anyone else in the cab, but I always do. Fort William was reached at 10.21 a.m., 27 min. late. The Cowlairs loss of time had not been made up, but increased.

Thence to Mallaig, a "K 2" was on the train, which weighed only 160 tons from Fort William; "No. 4692," "Loch Eil," the crew being Messrs. Thomson and McBeth. There was no glass deflector at the cab side on this engine. I have drawn attention to its value before, and to strengthen my point one driver told me that he had once spent several days in hospital with acute eye inflammation, due to the ingress of a vicious piece of grit, in the absence of the deflector.

Mallaig, with the waves dancing in the sunshine, and its outlying islands shimmering in a summer haze, is no doubt one thing; but with rain coming down in sheets, and half a gale blowing "over the sea from Skye," it is quite another. It is then not at all the sort of place to be recommended to anyone suffering from nervous depression; one look at it would probably be fatal. It is very compact and its charms are not extensive. Firing a shot gun anywhere within the town limits would probably result in the decease of two-thirds of the inhabitants, and it would not have to scatter much, either; it is that sort of place. I gave it a brief "once over" from the station entrance, and simultaneously the same escape idea struck the enginemen and myself; they were by this time off duty. Three minds with but a single thought, we adjourned to the leading hostelry—*anglice*, the village pub—there is only one. Here, for a happy hour or so, before a cheerful fire, we discussed locomotives and the musical glasses. My depression was soon a thing of the past, the weather was forgotten, and I ceased to care whether it was Christmas or Easter. As is generally the case when one is with railwaymen, some very interesting ideas came up for discussion, particularly towards the end of the session. But time and trains wait for no man, and I suddenly realised that unless I made a bee line to the station I should miss "Loch Eil," and readers of THE ENGINEER would be deprived of the notes I intended to make on the way to Fort William. I am afraid they will not find many as it is; something, possibly the weather, seems to have prevented many being taken. The engine, at any rate, did not have a heavy load—115 tons. I find a statement to the effect that the Beasdale bank was negotiated without difficulty. This seems rather a superfluous entry, as we were going down; and another, equally *inapropos*, that "here Prince Charlie landed." I wondered why; it did not look a very attractive place to come ashore. If possible, it was worse than Mallaig, being without cheer of any sort. The three-coach train reached Fort William to time at 3.54 p.m., and I rejoined "No. 3444," "Lord of the Isles," "K 4" class, this time with the Flaman apparatus in full working order, a device unaffected by weather or physical disabilities, and able to make a detailed and accurate record of the engine's performances. Leaving promptly at booked time—4.7 p.m.—with a 230 tons gross load and with such a galaxy of talent in the cab—Messrs. Smith, Dartle, and Flaman—I should almost have been justified in relaxing my own efforts all the way back to Glasgow. Nevertheless, I conscientiously took my usual accurate notes of speeds, mile posts, and what not, as a check on the Flaman, and I am able to say that its work was done with perfect accuracy.

Between us, the records of this run are so voluminous that it is impossible to give more than the gist of them; almost a complete issue of THE ENGINEER would be needed to include them all. The Flaman graph shows the exact speed, and the minutest variations, stops, and when they all took place, as, the starting time having been noted, all subsequent times can be worked out from that base. Space will not allow of my going fully into the working of a Flaman recorder in this article, but I hope to do so in a future one.

On this run the cut-off remained almost constant at 30 per cent. from Fort William to Crianlarich, 63·5 miles, which was reached only 2 min. late, at 6.21 p.m., the average speed having been 29·3 m.p.h. From Crianlarich onward it was briefly 40 per cent., and thence it was mostly 30–35 per cent.—rather more often the former—until we got on to double track beyond Craigendoran, 100 miles, and the engine speeded up, where it was shortened to 25 per cent., at which it remained to the finish. The steam chest pressure varied, of course, from zero to the maximum, 200 lb. boiler pressure, and it is very interesting to compare it with the gradients in the profile book, and with the wavering speed graph, to gather by inference what must have been happening to the regulator. For instance, at "Bridge 179" there is a 20 m.p.h. restriction, and the s.c.p. is zero, proving that the regulator was shut for a moment there. South of Crianlarich, there is a 4-mile 25 m.p.h. restriction, owing to a succession of bends, and the s.c.p. was 25 lb., so the regulator was evidently nearly shut. Beyond Ardlui there is a 20 m.p.h. restriction—we were only doing 17—and the s.c.p. was 5 lb.; shut, or as near as no matter.

Boiler pressure, 200 lb., was very well maintained over the whole distance. Out of fifty-four entries, thirty-nine are 200 lb., six are 195 lb., four 190 lb., one 185 lb., two 180 lb., and one is 175 lb. It was evidently so well maintained that I can only conclude I must be getting deaf, and missed a good deal of blowing-off. I do recall some, but, anyhow, Fireman Dartle was a first-class "top link" man, as this proves, or there would not have been all these 200 lb. entries!

From Fort William to Craigendoran, 100 miles, over single track, with innumerable heavy gradients, curves, restrictions, slowings to exchange tablets, and fourteen stops, the average speed was a little over 27 m.p.h. From there into Glasgow, 22·5 miles over double track, on far easier gradients, with a higher allowable speed and two stops, it was 34·6 m.p.h. Our arrival in Queen Street Station was dead on time, 8.27 p.m. It had been a very interesting day. All the engines had had quite a hard time, and, I think it will be admitted, so had the writer. I was on the move for 17·5 hours (approximately), and even when one is on the fireman's seat—but I have said all I need say on this subject. In that position one is still literally "on the move," and gradually one comes to notice it—it is borne in upon one, as it were. But this one had taken its toll. Late in the afternoon, full of Scottish oxygen and so forth, I began to have a terrible struggle to keep my eyes open, and ultimately I had to confess defeat or fall off the seat. At Arrochar I retired to the train, to get my head down, leaving the engine to the care of the trio of experts who, I hoped, would be able to carry on fairly well for a little while without me. I returned to the cab at Craigendoran, to find things going on just as before, quite smoothly, and the Flaman still ticking off the miles and the minutes.

An idea came to me more than once during these two days, *apropos*, though apart altogether from the fine work of the "K 4s"—what an ideal field the West Highland line would seem to be for a "Garratt" type engine. Its sinuousness, its incessant gradients, the quick acceleration called for—all would fit in with "Garratt" characteristics. A 4–4–0+0–4–4, with 5ft. 6in. wheels, a tractive effort of, say, 35,000 lb., and a boiler and grate adequate to provide the necessary power without distress—that is the sort of engine to meet the case. It would give the flexibility required by the sharp and often reverse curvature; the four driving axles for the ample adhesion necessary, and the almost unlimited boiler power which is such an asset. The weight per axle need not exceed 20 tons, and if the bogies were allowed 25 ton each the total weight would be about 130 tons, which would impose no undue stress on track or bridge construction. I should like to see an engine of this type in action there, though I do not suppose I ever shall. But this suggestion at least shows that my trips do sometimes bring into my head independent and constructive thoughts—even if only into mine—and, after all, that is what a head is given one for; to think with, not merely to keep one's backbone from unravelling.

Musing over these West Highland runs, my first experiences on Scottish lines, I am in no doubt as to my reactions. I had revelled in the scenery, the engines and their crews; I believe I could even get acclimatised in time. Naturally, some Gaelic customs, which I should imagine are peculiar to the country, seemed a little strange at first, and might even upset me if I were reckless enough to make them my own. Mixing one's drinks, for instance—I definitely disapprove of it, and do not think I could ever get used to it.

(To be continued)

Instruments in Science and Industry*

By ROBERT S. WHIPPLE

No. II

(Continued from page 301, Sept. 22nd)

SURVEYING INSTRUMENTS

AN interesting development in surveying instruments has taken place during the last few years. Heinrich Wild, a Swiss engineer, designed about 1921 a theodolite in which by means of an ingenious optical system it is possible to read the positions of the vertical and azimuth circles simultaneously in the eye-piece of a microscope mounted on the same axis as the telescope. The optical system for reading the circles demanded that they should be divided on glass, and the observer on his part insisted that the weight should be reduced. In the case of an instrument intended for a triangulation of the first order, the horizontal circle is 5·5in. in diameter, and it is divided to 4 minutes of arc. The final readings are taken on a micrometer drum and may be relied upon to 0·1 second. The dividing is etched on the glass, the thickness of the lines and figures not exceeding 0·0006in. (0·015 mm.), the divisions being about 0·003in. (0·075 mm.) apart. I may here interject that the obtaining of a resist that would allow the etching on the glass of such fine and close lines by an acid has necessitated a great deal of research. It may be regarded as typical of one of the small but serious difficulties that the instrument maker has so often to solve. The weight is about one-third that of any other type of instrument of similar accuracy, and the time taken over an observation at least one-quarter. Divisions etched on glass are more stable than those cut on silver, and the dividing error is reduced by the fact that circles do not have to be "cleaned off" after dividing, and thus there is no risk of distorting a line. In this connection it may be of interest to mention that the new reversible transit circle at the Greenwich Observatory, just completed by Messrs. Cooke, Troughton and Simms, is fitted with glass circles 28in. in diameter, the divisions being etched at intervals of 5 minutes of arc. The Astronomer Royal informs me that the extreme range in the division errors is only about 0·75 second and that the error of reading is very small.[7]

Before leaving surveying instruments mention must be made of the new developments in aerial surveying in which contours, etc., are obtained from photographs taken from aircraft at different standpoints. Although surveying by photography had been used before the Great War for the mapping of districts difficult to survey by ordinary methods, yet it was not then generally employed. Improvements in photography from the air, especially in the development of wide angle flat field photographic lenses having negligible distortion up to an included angle of 90 deg., have made it economically possible to survey fresh country, and even to check-over surveys that have been previously made by the usual methods. The ever-changing outlines of our towns can now be

* British Association. Presidential address to Section A, Mathematical and Physical Science.

[7] He also states that "The principal contributory causes to the total probable error of a single observation of declination are (*a*) error of bisection of star by declination micrometer wire; (*b*) error in assumed refraction; (*c*) slow wandering of star image produced by atmospheric irregularities; (*d*) errors in adopted instrumental errors of level, azimuth, etc., which vary with changes of temperature and direction of wind, and which are interpolated from smoothed curves."

accurately recorded by photographs taken from the air. As an example it may be mentioned that with a Ross 4-in. lens photographs have been taken over London from a height of 22,000ft., representing over 40 square miles on a plate 7in. square. The distortion given by such a lens is exceedingly small, a point in the image plane not being more than $\pm$ 0·01 mm. out of its correct position, except on the edge of the plate where the distortion slightly increases but does not amount to 0·1 mm. A new development, and one of great promise, is the construction of a multiple lens camera. Major-General M. N. MacLeod recently described [8] the performance of a seven-lens camera, comparing it with the results given by a single-lens instrument. He stated that at a flying height of 15,000ft. the area of the picture obtained with the seven-lens was 96 square miles as compared with 8·4 square miles with the single lens, and that the number of photographs required to obtain a survey of a 1000 square miles was 32 as compared with 410; an immense saving in flying time. Several forms of plotting machine have been developed for the interpretation of the photographs obtained, the majority combining either stereoscopically or otherwise the two views taken from different standpoints. One of the most successful of these has been designed by Captain E. H. Thompson of the Ordnance Survey. The results obtained with the air survey plotting instruments have proved not only more accurate but more expeditious than surveys made on the ground.

The Measurement of Time

The earliest of all instruments were, however, those devoted to the measurement of time, and depended on the position of the sun; in the majority of cases on the position of a shadow cast by it. Later the time was also told by observing the position of the earth relative to the stars. Throughout the Middle Ages, and later during the fifteenth to seventeenth centuries, great ingenuity was shown in the design and construction of sundials and nocturnals. The large literature on the subject shows how important the measurement of time was, even then, to the community. For the purpose of our discussion we need not dwell further upon these instruments nor upon the clocks used previously to the invention of the pendulum. Although Galileo had noticed in 1581 that the time of swing of a pendulum was almost independent of the amplitude of its swing, yet it is doubtful whether he succeeded in making a working clock. In 1657 Huyghens patented his pendulum clock, and described it fully in 1673 in his *Horologium Oscillatorium*. The clock was driven by a falling weight and kept the pendulum in motion by impulses transmitted through a verge escapement. Shortly after this date Hooke invented the anchor escapement, which, in its form modified by Graham, became the escapement used in the majority of pendulum clocks, and remains so to the present day. The effect of temperature upon a pendulum clock is serious, in that the length of the pendulum varies with temperature and hence the duration of the period of swing. Graham in 1721 introduced a pendulum bob containing mercury; thus, by adjusting the quantity of mercury its expansion could be made to counteract that of the steel pendulum rod. Five years later Harrison invented the composite, or "grid-iron," form of pendulum made of brass and steel rods to which the weight was attached. Nearly all the temperature compensation difficulties disappeared with the invention of *invar*, a material of negligible temperature expansion-coefficient. There is not time to enlarge upon the devices for compensation for changes in barometric pressure and on the various methods for maintaining a standard clock in motion. Mention must be made of the Shortt free pendulum clock introduced in 1921, in which the daily variations in the rate are only a few thousandths of a second.

In the history of timekeeping the chronometer of Harrison must be mentioned as it marked a great step forward as compared with its predecessors. In the official tests of his fourth instrument it was shown that over a period of five months on a voyage to Barbados and back its total error was fifteen seconds. About 1920 Guillaume introduced an alloy, *elinvar*, whose elasticity is almost independent of temperature, and it is also non-magnetic. Thus by making the balance wheel of a watch or chronometer of this material, the effects of temperature and stray magnetic fields have been eliminated. Official tests show that a watch fitted with a Guillaume balance, which in this case is a cut balance of brass and 42 per cent. nickel-steel alloy, may have a mean variation of daily rate of only 0·06 second.[9]

The accurate control of the length of the wireless waves radiated by the broadcasting stations has been a difficult problem, and has resulted in the production of an extremely accurate timekeeper. That certain asymmetric crystals when subjected to electrical stresses change their dimensions was discovered by the brothers J. and P. Curie in 1880. They also showed that such crystals develop surface charges under the influence of mechanical pressure. Later it was shown that when stressed by a rapidly alternating current the crystal is made to vibrate, and if the frequency agrees with the natural frequency of the crystal the amplitude of oscillation is relatively large. Primarily owing to the work of two men, W. G. Cady in America and the late D. W. Dye in this country, quartz crystal controlled oscillators have been developed which maintain themselves in oscillation at a definite frequency and with an accuracy of approximately one part in one hundred million. A form of clock has been designed in which the maintaining power is an electric circuit controlled by a quartz oscillator. One of these clocks has been installed at the Royal Observatory, Greenwich, and it is hoped that by its means it may be possible to check the time of rotation of the earth upon its axis. I think it would be difficult to find a more striking example of a piece of pure scientific research work developing into an appliance with almost unlimited possibilities.

Thermometry

From the point of view of industry, the thermometer is one of the most important of all scientific tools, for that is its ultimate position. There is hardly an industry in which temperature does not play an important part, and in our daily lives the question of the temperature of our bodies, or of the air surrounding them, is of fundamental importance.

The first instrument for measuring temperatures was an air-thermometer, and was invented by Galileo about 1592. His friend Sanctorius actually used a form of thermoscope to show variations in the heat of the human body—the first clinical thermometer. The Grand Duke Ferdinand II of Tuscany is said to have invented about 1650 the first alcohol thermometer in which the tube was hermetically sealed. It is not known to whom the invention of the mercury-in-glass thermometer is due, although they were in existence in 1693.

Lord Kelvin propounded the thermo-dynamic scale of temperature as the final standard of reference, and it is to this scale (the absolute scale of temperature) that all temperatures are now referred. The National Physical Laboratories of the world have, at immense trouble, linked up their thermometric scales, so that readings taken by an instrument standardised by the Bureau of Standards in Washington will be found to agree with those certified at the National Physical Laboratory. The first important work of this kind was an investigation at the Bureau International des Poids et Mesures, about 1884, into the errors of mercury-in-glass thermometers. As a result it was shown that if the thermometer bulb was made of a "hard" glass, and if a carefully prescribed routine was followed in the standardisation of the thermometer, it could be made an instrument capable of measuring temperatures throughout its range to 0·001 deg. Cent.

The recent developments in the manufacture of mercury-in-steel thermometers and of vapour pressure thermometers have largely reduced the demand for mercury-in-glass thermometers in industry. That there is still a huge field for the mercury thermometer may be judged from the fact that the National Physical Laboratory certifies over half a million clinicals annually, and that air temperatures are largely taken with such thermometers.

Electrical methods of measuring temperature have made great strides during the past few years. A great deal of this progress was due to the work of H. L. Callendar, who was President of Section A when the British Association last met in Dundee in 1912. He showed that the resistance thermometer suggested by Sir William Siemens in 1871 could be made an instrument of high precision and at the same time developed simple bridge methods for measuring the resistance of the thermometer. Above all he invented the Callendar Recorder, the pioneer of the majority of recording bridges and potentiometers in use to-day. Callendar possessed in a marked degree the gift of explaining difficult problems, and also that of great experimental skill.

Although the resistance thermometer is still the standard for the range —100 deg. to 600 deg. Cent., it is not used as frequently in industry for the measurement of high temperatures as it was a few years ago. Its industrial field has become that covering temperatures below 500 deg. Cent., and more particularly for use in positions where by means of a switchboard it is convenient to read a group of temperatures from one central position.

The discovery of thermo-electricity by Seebeck in 1822 led eventually to the production of the simplest electrical thermometer and one of the most practical in industry. The platinum, platinum 10 per cent. rhodium couple was introduced by Le Chatelier in 1886, and owing to its reliability and to the fact that its electrical constants can be reproduced in various meltings of the alloy, has become the most generally used in accurate high temperature work. Owing to the high price of platinum this thermo-couple (generally referred to as the "rare-metal" couple) cannot be used in industry as freely as one would wish, but the invention of the "base metal" couples, such as iron, constantan (Ni 40 Cu 60 per cent.), nickel, nickel-chromium (Ni 90 Cr 10 per cent.) has largely met the requirements. The latter of these two couples, due to Hoskins, may, if suitably protected, be used for temperatures as high as 1200 deg. Cent. The base metal couples yield a high E.M.F., thus tending to simplify the measuring equipment.

A variety of potentiometers, deflection galvanometers and recorders have been developed to meet the demands of industrial thermometry. It is, I think, true to state that with very few exceptions no heat treatment is now given to any material in a manufacturing plant without thermometric control.[10] The modern methods of heating lend themselves so readily to automatic control that the instrument maker is being called upon to design automatic controls for every variety of heat treatment from that of a dental furnace to one capable of taking the largest gun. The application of high temperatures in industry, especially in metallurgical work, has increased the demand for instruments capable of measuring temperature without being placed in the hot zone. The first satisfactory attempt at such a pyrometer was made in 1892 by Le Chatelier. In this instrument, which was a form of photometer, the intensity of the light received from the hot body was adjusted by means of an iris diaphragm (later by means of absorbing-glass wedges) to match that given by a standard lamp. A few years later Holborn and Kurlbaum introduced the disappearing-filament form of instrument which in one form or another is now the most generally used type of optical pyrometer. In this the filament of a small incandescent lamp is interposed between the eye of the observer and the hot body. The current through the lamp is adjusted so that the filament becomes invisible against the incandescent hot body. The Féry pyrometer (1902) consists of a thermo-couple of small mass mounted in the focus of a concave mirror which focusses the total radiation received from the hot body on to the couple. This instrument can be used to measure temperatures throughout a large range. It has also the advantage that it can be readily attached to a recording galvanometer and can thus be made to follow the stages in the heat treatment of materials in a furnace or kiln. Owing to the large amount of comparatively recent theoretical work on radiation problems, the principles underlying optical and radiation pyrometers have been exhaustively studied, so that the measurements obtained with these instruments are closely linked to the absolute temperature scale. Thus the upper basic points on the scale of temperatures published by the International Committee on Weights and Measures in 1927 were established by means of optical pyrometers.

Galvanometers

The last instrument that I shall deal with is the galvanometer, and that can only be taken as representing the great group of electrical instruments that has come into existence during the past century. At the Faraday Centenary Exhibition, held in London in 1931, an exhibit showing

[8] M. N. MacLeod, "Some Recent Developments in British Surveying Instruments," *Proc. Phys. Soc.*, 51, p. 716 (1939).

[9] *The National Physical Laboratory, Watch and Chronometer Trials*, p. 7 (1938).

[10] In this connection the work of Wedgwood, the famous potter, should not be forgotten. In 1782 he introduced a method of measuring the contraction of small blocks of china clay of various compositions. The contraction varied with the temperature and a measurement of this gave an idea as to the maximum temperature reached at the time of the withdrawal of the block. This form of pyrometer was in general use in the potteries for over a century.

the development of electrical measuring instruments was staged by Mr. R. W. Paul on behalf of the Exhibition Committee. The exhibits showed how cosmopolitan has been the growth of electrical measuring instruments. The galvanometer is no exception to this statement. The name itself was given to a form of electrometer by Bischoff in 1802, and commemorates the discovery by Galvani of the movements of the muscle of a dead frog by electricity. Oersted in 1820 discovered that an electric current would deflect a compass needle, and thus laid the foundation for the many types of moving iron or magnet galvanometers. In 1858 W. Thomson (Lord Kelvin) invented the mirror galvanometer for use with the Atlantic submarine cable; this instrument made submarine signalling possible. In 1881 the Deprez-d'Arsonval moving-coil galvanometer was invented, and although it had been anticipated by other inventors the credit is due to these two distinguished Frenchmen for the most practical form of galvanometer—the one used in practically every direct-current measurement. The moving-coil galvanometer has been studied theoretically and practically by Ayrton and Mather, Zernicke and Moll, and the result of their work is an instrument of extremely high sensitivity and short period. Paschen, Nichols and Downing and Hill have done much to increase the sensitivity of the moving-magnet galvanometer. (In this connection acknowledgment must be made of the great debt the physicist and the instrument maker owe to that doyen of instrument designers, Sir C. Vernon Boys. The high sensitivity of certain types of galvanometer is very largely due to his invention of the quartz fibre—the ideal material for suspending light bodies.)

The sensitivity of such instruments is now so great that it has become necessary to enquire into the effects of Brownian motion. This has been discussed very fully by Barnes and Silverman,[11] who conclude that there "is a definite limit set by Brownian motion." In practice, however, "mechanical stability and the patience necessary to read long-period instruments are the limiting factors of sensitivity, for an ideal instrument."

A form of galvanometer which has proved of great service in industry in confirming much theoretical work in connection with alternating currents is the electro-magnetic oscillograph, a galvanometer possessing an extremely short periodic time and fairly high current sensitivity. The moving strip type, in which the element is reduced to the simplest form, consists of a loop of a fine metallic strip stretched in a magnetic field, the air-gap being reduced to a minimum. This instrument was invented by Blondel in 1893, but its development was largely due to Duddell, who, six years later, showed in a series of striking experiments the possibilities of the instrument. Since then its capabilities have been much improved, the latest models having a natural frequency in air of $\frac{1}{17000}$ second and a sensitivity of 42 mm. at one metre for 0·1 ampere D.C., or with a frequency of $\frac{1}{3000}$ second a sensitivity of 580 mm. at one metre for the same current—a sensitivity ten times that possible five years ago. In some of the test rooms of the large switch and cable makers a group of these instruments (sometimes as many as twenty-four elements) is used to record photographically the phenomena set up in the network when a heavy current switch is opened or closed.

The problems connected with telegraphy and wireless have also invoked the aid of the oscillograph. Many of the phenomena to be studied take place in such short intervals of time ($\frac{1}{1000000}$ to $\frac{1}{100000000}$ second) that it is impossible for any form of mechanical instrument to respond. This has brought into general use the cathode-ray oscillograph, a form of which is now so familiar in television sets. The cathode-ray beam is deflected by the current or voltage under investigation, the movements being recorded either by the direct action of the beam on a photographic plate, or by photographing the luminous trace on a fluorescent screen. For the observation of phenomena occurring in extremely short intervals of time the former method is adopted, the writing speed of the spot being approximately one-third the velocity of light.

An address of this nature would be incomplete if no mention were made of the thermionic valve. The story of the development of this device has been told elsewhere [12] and in greater detail than is here possible. Its advent has led not only to the birth of a wide range of new instruments otherwise impracticable, but also to the simplification of many measuring techniques. The thermionic voltmeter was one of the first, if not the first, measuring instrument employing directly a valve and uses to the full its most valuable characteristics as a measuring device. These characteristics may be briefly summed up as rectification, amplification, rapidity of response, and high impedance. Although these are the prime considerations, others, such as high overload capacity, are advantageous. The rectifying action combined with amplification enables alternating currents and voltages as small as 10^{-4} ampere and 10^{-4} volt to be measured, using a robust moving-coil instrument as a direct reading indicator. The low electrical inertia and high input impedance have, when using suitable diode valves, enabled voltages and frequencies up to 100 megacycles to be measured with reasonable accuracy by robust commercial instruments.

The part played by the thermionic valve in the simplification of measuring techniques is now well known to all laboratory workers. As a striking example it is, I think, safe to say that had it not been for the replacement of the mechanical type of electrometer by the electrometer valve or other type of valve combinations, the measurement of pH would not have emerged from the laboratory to spread to almost every industry.

Conclusion

Looking back over forty years' experience in the use of scientific instruments, many of those years being spent in their manufacture and development, I am much impressed with the steadily growing demands for higher accuracy. The development of the high-speed steam engine, and later the motor car, brought about an insistent demand for accurate tools and gauges. This in its turn necessitated better design in the tools and more accurate measuring instruments. The manufacture of interchangeable components in large quantities has still further increased the demand for accuracy. The introduction of the new alloy steels with the special technique required in their heat treatment created a demand for precision thermometry.

The attitude of the manufacturer towards the scientific instrument has completely altered. He was once sceptical as to its usefulness; he is rarely so nowadays. In the majority of large works the general control over the instruments is now in the hands of a technically trained man, and that in itself relieves the instrument maker of much anxiety. Another fact that impresses one is the great difference between the methods of manufacture during the same period. Forty or fifty years ago instruments were made in small batches, often by individual workmen. In London they were frequently made for some well-known firm by small chamber men who put the name of that firm upon them. As a result of this procedure the so-called manufacturer very often had not an adequate knowledge of his products: this practice has almost entirely disappeared, to the benefit of customer and maker.

The increased demand for instruments has led to manufacture in the modern sense of the word. An instrument is carefully designed in the drawing office in consultation with the technical expert. The methods by which the instrument is to be made are considered. If the quantities are large, and if a preliminary model has been approved, then the possibility of the use of die castings, hot pressings or plastic mouldings must be considered,[13] and the importance of interchangeability of components emphasised.

In preparing the design of an instrument it must never be forgotten that a good design helps production. It always pays to spend time in the drawing office rather than in the workshop. The application of geometric design, the early exponents of which were Maxwell and Horace Darwin, often reduces the cost of manufacture and makes a better instrument. I think that the experimentalist, in making up his own instrument, should consider whether he can obtain the same result by a simply designed geometric piece of apparatus, rather than the more elaborate design to which he may be attracted.

The demand for instruments is ever growing. As new problems arise, both in science and industry, the requirements become more stringent. The instrument maker constantly receives incentives to progress from the scientific worker to whom he owes not only suggestions but many of his new materials. It is, I suppose, a truism that if knowledge is to progress it is essential that theory and practice advance together. Nowhere is this more true than in the development of scientific instruments.

[11] R. Bowling Barnes and S. Silverman, "Brownian Motion as a Natural Limit to all Measuring Processes," *Review of Modern Physics*, 6, p. 169 (1934).

[12] E. G. James, G. R. Polgreen and G. W. Warren, "Instruments incorporating Thermionic Valves, and their Characteristics," *Proc. I.E.E.*, 85, No. 512 (1939).

[13] One of the most striking changes in the technique of instrument design has resulted from the use of plastics. Mouldings are so convenient that in some cases where comparatively few instruments are required annually, the cost of the tool is justified by the time saved in the avoidance of intricate machining operations on insulating materials.

Exhaust Gas Analysis and Air/Fuel Ratio

By R. G. BELLAMY, M.Eng.*

THE exhaust gas analysis method of air estimation in internal combustion engines has been recognised practice since Professor Watson and others did their research on this problem over thirty years ago. By analysing the dry gases for CO_2, CO, and O_2,† and knowing the carbon content of the original fuel, an estimate can be made of the air supplied per unit weight of fuel. Watson worked on petrol engines, and in his results published in 1908‡ issued a warning against too rigorous an application of the method. His further work, published in 1914,§ confirmed his estimate of its value. Fieldner, Jones, Minter, Lockwood, and Best‖ have in more recent years contributed to the subject in the United States, and their work lends a more optimistic point of view to the accuracy with which gas analysis may be used for this purpose.

The following analysis throws into strong relief several interesting facts concerning the problem, with a pointer to a more accurate use of the exhaust gas analysis method.

The case of the petrol engine is considered first, followed by that of the Diesel engine. In both cases the fuel to the engine is considered to be supplied with air in excess of that theoretically required for complete combustion. It is realised that this is the less common manner of running the petrol engine, though the more common in the case of the Diesel engine.

Petrol may be considered as a mixture of hydrocarbons of the form $C_a H_b$. The combustion of such a hydrocarbon when supplied with an excess of oxygen x over that required for complete combustion is expressed by

$$4\,C_aH_b+(4a+b)O_2+x\,(4a+b)O_2+(1+x)\,(4a+b)\frac{0\cdot791}{0\cdot209}N_2=4a\,CO_2+2\,b\,H_2O+x\,(4a+b)\,O_2+(1+x)\,(4a+b)\,\frac{0\cdot791}{0\cdot209}\,N_2.$$

From this the proportion of O_2 in the dry flue gas by volume is given by

$$O_2=\frac{x\,(4a+b)}{4a+x\,(4a+b)+(1+x)\,(4a+b)\,\frac{0\cdot791}{0\cdot209}}=\frac{x\,(4a+b)}{19\cdot12\,a+19\cdot12\,a\,x+4\cdot78\,b\,x+3\cdot78\,b}.$$

Let $y=1/O_2$,

$$\therefore\ y=\frac{19\cdot12\,a+19\cdot12\,a\,x+4\cdot78\,b\,x+3\cdot78\,b}{x\,(4a+b)}.$$

Divide out the R.H.S.

$$y=4\cdot78+\frac{4\cdot78}{x}-\frac{b}{4a\,x}+\frac{b^2}{4^2a^2x}-\frac{b^3}{4^3a^3x}+\frac{b^4}{4^4a^4x}+\ \ldots\ \&c.$$

$$=4\cdot78+\frac{4\cdot78}{x}-\frac{1}{x}\left\{\left(\frac{b}{4a}+\frac{b^3}{4^3a^3}+\frac{b^5}{4^5a^5}+\ \ldots\right)-\left(\frac{b^2}{4^2a^2}+\frac{b^4}{4^4a^4}+\frac{b^6}{4^6a^6}+\ \ldots\right)\right\}$$

Enclosed within the large brackets are two geo-

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† A more comprehensive analysis of an exhaust gas may include small quantities of H_2 and various hydrocarbons such as CH_4.

‡ Proc., Inst. Auto. Engineers, Vol. III.

§ Proc., Inst. Auto. Engineers, Vol. IX.

‖ U.S. Bureau of Mines and S.A.E. Journals, various.

metric series each having a common ratio of $b^2/4^2\,a^2$. These may be summed to infinity on condition that $b^2 < 4^2\,a^2$, *i.e.*, $b < 4\,a$.

Sum to infinity

$$y=4\cdot78+\frac{4\cdot78}{x}-\frac{1}{x}\left\{\left(\frac{b/4\,a}{1-b^2/4^2\,a^2}\right)-\left(\frac{b^2/4^2\,a^2}{1-b^2/4^2\,a^2}\right)\right\}$$

$$=4\cdot78+\frac{4\cdot78}{x}-\frac{1}{x}\left[\frac{b}{4a+b}\right] \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Petrols in general contain three groups of hydrocarbons; the first, the paraffin group, takes the form C_nH_{2n+2}; the second, the naphthenes, is of form C_nH_{2n}; whilst the third group, the aromatic series, is expressed C_nH_{2n-6}. Each of these is examined for the condition $b < 4\,a$.

Paraffins.—C_nH_{2n+2}: $2\,n+2$ must be $< 4\,n$, which is true for all values of $n > 1$.

Naphthenes.—C_nH_{2n}: Here b is always $< 4\,a$.

Aromatics.—C_nH_{2n-6}: $2\,n-6$ must be $< 4\,n$, which is true for all values of $n > -3$.

Since the above conditions allow of the presence of all hydrocarbons known in each group, equation (1) gives a general relationship between the proportion of oxygen by volume in an exhaust gas and the ratio of excess air, the atomic values a and b specifying the particular hydrocarbon.

The actual members of the above groups of hydrocarbons which may appear in petrols and oils are decided on boiling points and freezing points. Only those members whose boiling points allow them to exist in the liquid condition at normal temperatures, and whose freezing points ensure that they do not become solid at ordinary temperatures, are considered.

Paraffin Group.—C_nH_{2n+2}: in this group, pentane C_5H_{12}, with a boiling point of 36 deg. Cent. and a low freezing point, is the lowest possible member, whilst the highest is hexadecane, $C_{16}H_{34}$, with a freezing point of 20 deg. Cent. and a comparatively high boiling point. In most commercial petrols the actual members present fall within a still narrower range than expressed by these two hydrocarbons.

Naphthenes.—C_nH_{2n}: The actual members of this group need not be considered, since the ratio of b/a is independent of n.

Aromatics.—C_nH_{2n-6}: Only the first three members of this group are present in petrols, these being benzene, C_6H_6, toluene, C_7H_8, and xylene, C_8H_{10}.

The maximum variation of equation (1) may now be studied for each group. This involves evaluating the ratio $b/(4\,a+b)$ for the extreme members of the group.

Paraffins.—C_nH_{2n+2}:

For C_5H_{12}, $b/(4\,a+b)=0\cdot37$.
For $C_{16}H_{34}$, $b/(4\,a+b)=0\cdot35$.

From which equation (1) may vary between

$$\left.\begin{aligned} y&=4\cdot78+4\cdot41/x\\ \text{to } y&=4\cdot78+4\cdot43/x\end{aligned}\right\} \text{A.}$$

Naphthenes.—C_nH_{2n}:

For all members, $b/(4\,a+b)=0\cdot34$.

From which equation (1) becomes

$$\left.y=4\cdot78+4\cdot44/x\right\} \text{B.}$$

Aromatics.—C_nH_{2n-6}:

For C_6H_6 $b/(4\,a+b)=0\cdot2$.
For C_8H_{10} $b/(4\,a+b)=0\cdot24$.

With a consequent variation in the value of equation (1),

$$\left.\begin{aligned} y&=4\cdot78+4\cdot58/x\\ y&=4\cdot78+4\cdot54/x\end{aligned}\right\} \text{C.}$$

The variation in the second term of the equations in brackets A, B, and C is small, and since petrols are a mixture of the three groups, a mean value for this term is chosen. For this reason equation (1) is written

$$y=4\cdot78+4\cdot49/x \quad . \quad . \quad . \quad . \quad (2)$$

The relative accuracy of this equation is tested by considering extreme values of the second term, in conjunction with the worst condition of x, that approaching O. This reveals that if a petrol consisted entirely of paraffins, the maximum percentage error in using the above expression is 1·8, whilst for a petrol having only aromatics this figure is −1·9 per cent. When x is 0·5 the maximum percentage error is of the order of ±1 per cent.

Substituting for y in equation (2)

$$O_2=\frac{x}{4\cdot78\,x+4\cdot49} \quad . \quad . \quad . \quad (3)$$

or, in an alternative form,

$$x=\frac{4\cdot49\;O_2}{1-4\cdot78\;O_2} \quad . \quad . \quad . \quad . \quad (4)$$

Equation (4) now provides a relationship by which the ratio of excess air supplied to an engine may be obtained from an analysis of the oxygen content of the exhaust gas. It is conditional on the engine working with an excess of air over that theoretically required, and therefore is applied only when the carbon monoxide content of the exhaust gas is negligible. It is independent of the form of the petrol used.

From the ultimate analysis of the petrol used, the theoretical quantity of air required per unit weight of fuel is calculated, and the product of this quantity and $(1+x)$ gives the actual air supplied per unit weight of fuel.

Application of Equation (3) to Diesel Engine Exhaust Gases

The author has, in conducting some work on Diesel engine exhaust gases, had occasion to plot oxygen-excess air ratio curves, calculated from the ultimate analsyis of the fuel. On examination, it was found that equation (3) fitted very closely to these curves. The following investigation demonstrated the truth of this conclusion.

Consider a Diesel fuel to consist of carbon, C per cent., and hydrogen, H per cent. by weight, and ignore the sulphur content. Using x to denote the excess air ratio, the volumes of the dry exhaust products resulting from the combustion of unit weight of the oil are

$$CO_2=C/12$$
$$O_2=x\,(C/12+H/4)$$
$$N_2=\frac{0\cdot791}{0\cdot209}\,(1+x)\,(C/12+H/4)$$

From which the proportion of O_2 in the dry exhaust gas

$$O_2=\frac{x\left[\frac{C}{12}+\frac{H}{4}\right]}{\frac{C}{12}+x\left[\frac{C}{12}+\frac{H}{4}\right]+\frac{0\cdot791}{0\cdot209}(1+x)\left[\frac{C}{12}+\frac{H}{4}\right]}$$

Dividing the top and bottom by C/12+H/4, and writing M for the ratio of carbon to hydrogen in the original oil,

$$O_2=\frac{x}{4\cdot78\,x+3\cdot78+M/(M+3)}.$$

The value of M for Diesel oils on which the author has conducted his work lies between 6·5 and 8, and these limits may be regarded as wide. The limits of this last equation then become

$$O_2=\frac{x}{4\cdot78\,x+4\cdot46},$$

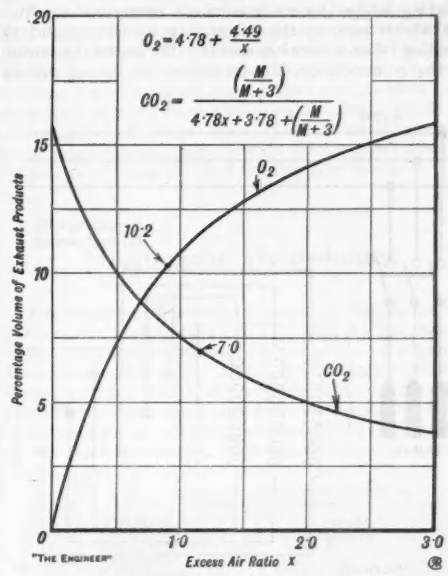
and

$$O_2=\frac{x}{4\cdot78\,x+4\cdot51}.$$

The comparison of these limiting equations with equation (3) amply justifies the application of that equation to Diesel engine exhaust gases. This is not surprising, since Diesel fuel must largely be constituted of the three main groups of hydrocarbons mentioned. A further group C_nH_{2n-2} gives an expression within the extreme limits of those found in establishing equation (3), whilst the presence of small percentages of oxygenated compounds does not materially affect the final result.

Having established the constancy of the oxygen-excess air ratio equation for all petrols and Diesel fuels likely to be used, the value of using the oxygen content in place of the CO_2 content for estimation of the air supplied is confirmed.

In the accompanying diagram, curves of O_2 and CO_2 by volume per cent. against excess air ratio are plotted for a known Diesel fuel. The equations given on the diagram are the general equations established for these curves. This fuel was burned in a Diesel engine, and an exhaust gas analysis showed 10·2 per cent. oxygen and 7·0 per cent. carbon dioxide. These values are marked by arrows on their respective curves. From the CO_2 figure, the excess air ratio is found to be 1·2, whilst from the oxygen figure the ratio is 0·85. The general practice has been to accept the CO_2 value. This, it is suggested, is likely to be without



OXYGEN AND CARBON DIOXIDE CURVES

justification in face of the constancy of the O_2 curve, and of the following examination of the allowable error in the respective CO_2 and O_2 values.

From the original hydrocarbon combustion equation at the beginning of the article, the proportion of CO_2 in the exhaust gas by volume is given by

$$CO_2=\frac{4\,a}{19\cdot12\,a+19\cdot12\,a\,x+4\cdot78\,b\,x+3\cdot78\,b} \quad . \quad . \quad . \quad (5)$$

Differentiating this expression with respect to x, and inserting a mean value of $b/a=2$, gives

$$\frac{d\,CO_2}{d\,x}=\frac{0\cdot139}{(x+0\cdot93)^2} \quad . \quad . \quad . \quad . \quad (6)$$

Applying similar treatment to equation (3) gives

$$\frac{d\,O_2}{d\,x}=\frac{0\cdot196}{(x+0\cdot94)^2} \quad . \quad . \quad . \quad . \quad (7)$$

The ratio of equation (7) to equation (6) is approximately equal to

$$\frac{0\cdot196}{0\cdot139}=1\cdot4:1.$$

Referring to the diagram, this means that the slope of the oxygen curve for all values of x is approximately 1·4 times that of the CO_2 curve. This ratio varies according to the value of b/a, but its extreme values are approximately 1·2 for benzene to 1·5 for pentane.

It is therefore apparent that a greater error is permissible in the determination of the oxygen content of the exhaust gas, than of the CO_2 content, to give the same standard of accuracy in the air determination. This fact, along with the simple relationship existing between the oxygen content and the excess air ratio for all petrols and fuel oils, justifies the employment of the oxygen value for air determination in internal combustion engines.

Variable-Speed A.C. Motors for Power Stations

THE variable-speed drive has many applications in modern power stations. Methods of control such as the baffling of fans or the throttling of pumps does not give such a flexible or efficient control as is secured by varying the speed of the drive. Although various mechanical arrangements are available for changing the speed, there is still an insistent demand for variable-speed motors. The range of duties in a power station makes it essential to select a variable-speed motor best suited for the job. The British Thomson Company makes five main types of machines suitable for power station use, the Schrage variable-speed commutator motor with brush shifting control, a stator-fed shunt commutator motor with induction regulator control, an induction motor with Scherbius control, charge pole or cascaded induction motors and a single-phase repulsion motor.

For general purposes the Schrage motor has the widest range of application. Essentially it is an induction motor with a normal arrangement of stator and rotor windings inverted. Speed variation is obtained by applying to the secondary winding a voltage obtained from a small commutator winding on the motor. It is self-contained and in most cases has no external apparatus except a supply switch, but can be remote controlled by means of a pilot motor. A typical diagram of connections is shown in Fig. 1. Its limitations are that normally the supply voltage may not exceed 600, and the possible output per pole is limited by the permissible voltage

induced between commutator segments. The largest motor that can be built for 1000 r.p.m. develops about 200 H.P., but a 500 H.P. machine can be built for 500 r.p.m. Within these limits, the design of these motors presents no special difficulties, because the loading of the commutator winding depends on the fraction of power corresponding to the speed regulation from synchronous speed and not to the whole output of the machine.

In the stator-fed motor with induction regulator control (Fig. 2) the supply is fed into the stator winding while the rotor carries a commutator winding which acts in the same way as the secondary winding of an induction motor. Owing to the action of the commutator, the frequency at the secondary

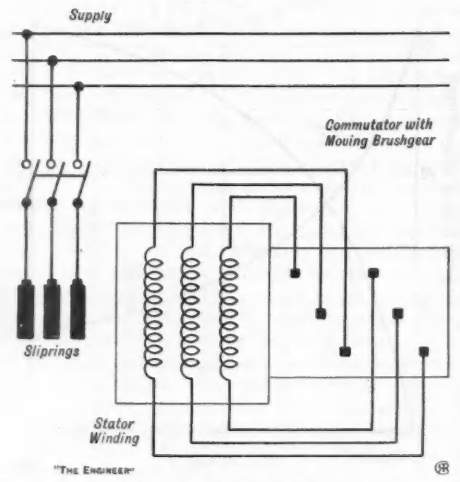


FIG. 1—CONNECTIONS OF SCHRAGE MOTOR

terminals is always the same as that of the supply, irrespective of the speed, so that the motor speed can be controlled by means of a variable voltage transformer or induction regulator connected to the commutator as shown in Fig. 2. As the current loading of the commutator winding depends on the whole output of the motor, commutation of the current is inherently more difficult in the stator-fed motor than in the Schrage motor. But it is not subject to the same limitaions of output as the Schrage machine, and motors of this kind have been built for quite large powers. Moreover the power factor and torque characteristics of the stator-fed motor are inferior to those of the Schrage variable speed commutator motor with brush shifting control.

For general purposes over a range of outputs which covers the majority of cases, the Schrage motor is considered by the B.T.H. company to be the A.C. commutator machine which gives the best results. The stator-fed motor is, however, believed to be useful in certain cases. It is suitable for small powers with remote control, where the cost of pilot gear is relatively high, and since the primary winding is on the stator it may be wound for high voltages. Very large motors for outputs above the limit of the Schrage motor can be built, suitable for total enclosure, because of the absence of slip rings.

Scherbius equipments in which the speed of an ordinary slip-ring induction motor is controlled by a separate A.C. commutator machine can be built for any output and have been used for certain large power station drives where a commutator motor would be impossible or uneconomical. Speed control is obtained by adjusting the excitation of the speed regulation machine and alternative methods are available depending on the particular duty.

Change pole induction motors have been used to some extent for obtaining two alternative speeds on certain power station drives of small and medium horse-power. For larger powers a cascade set, consisting of two direct-coupled induction motors, provides an efficient two-speed pump drive. Single-phase motors are used mainly where a single-phase supply is more easily obtained than a three-phase supply. Normally such machines do not enter into power station work. An exception is the case of a crane or hoist for unloading coal at a wharf or railway siding, where series characteristics which are more easily obtained with single-phase current, are sometimes desirable.

From the point of view of the power station itself, the drives can be classified according to the duty for which the variable-speed motor is required.—(*a*) Boiler house fans. (*b*) Stokers and pulverised fuel feed. (*c*) Boiler feed pumps. (*d*) Circulating water pumps. (*e*) Cranes. The drives required for boiler house fans are normally within the capacity of the Schrage motor. If, however, it is desired to use a high voltage supply, the stator-fed motor can be installed. It is usually necessary to protect the motor from the dust which is present in all boiler houses, either by supplying clean air through ducts, by filtering the air which passes into the motor, or by using a motor which is completely enclosed. For the outputs required for most boiler house fans, it is not generally possible to use ordinary totally-enclosed motors, and some special arrangement is necessary for removing the heat from the internal air inside the machine. In a large commutator motor it is also highly desirable to provide means for removing the brush dust, which even in the case of a motor giving a good brush life, would accumulate over a period of years, and introduce a danger of eventual breakdown of insulation, particularly in the case of high-voltage windings. The best arrangement for this purpose is to provide an external circuit for the air, which passes through a separate cooler (preferably air-cooled) and a filter. Since the amount of dust to be removed is relatively small, the attention required by the filters is much less than in the case of an ordinary filter-ventilated motor.

These ventilating systems, using filtered external air or a closed air system, are equally applicable to either the Schrage type or the stator-fed type of commutator motor, since the danger due to brush dust is present in both cases. Although, as already stated, the current loading of the commutator winding is greater in the case of the stator-fed motor, the power handled by the commutator itself corresponds to the percentage speed regulation, or slip, from synchronous speed, and is therefore the same whichever type of motor is used. This means that, provided the generally accepted limits of brush density are adhered to, there is no essential difference in the amount of brushgear carried by the two types of motor. It is often necessary, particularly in the case of the stator-fed motor, to use special damping windings, of which several different types have been used successfully, but this does not materially affect the fundamental principle stated above. In Fig. 3 is shown one of eight Schrage variable-speed motors driving induced-draught fans in the Tir John Power Station, Swansea. The motors are rated 170/22 H.P., 970/485 r.p.m., 400 volts, and are ventilated through filters. A recent B.T.H. contract covers eight variable-speed Schrage motors for Leicester Power Station. They comprise two motors rated 250/10 H.P., 575/210 r.p.m. for the forced-draught fans, four motors rated 48·5/7·75 H.P., 725/420 r.p.m. for the induced-draught fans, and two motors rated 100/36 H.P., 1470/1100 r.p.m. for the exhauster fans. The motors are supplied at 415 volts, and in this case are ventilated with clean external air through ducts. They are duplicates of four similar motors installed in 1935, and are similar to six other fan motors which have been in operation in the same station for ten years. Considerable numbers of other commutator motors are in use in boiler houses, showing that satisfactory service is obtainable with this type of machine, provided that the necessary precautions are taken to avoid accumulation in the machine either of external boiler house dust, or of internal brush dust.

Change-pole induction motors have been used for driving boiler house fans. Since, however, the provision of two fixed speeds does not in itself give a sufficiently fine control, these motors are generally used in conjunction with other apparatus, such as a hydraulic coupling or a damper on the fan.

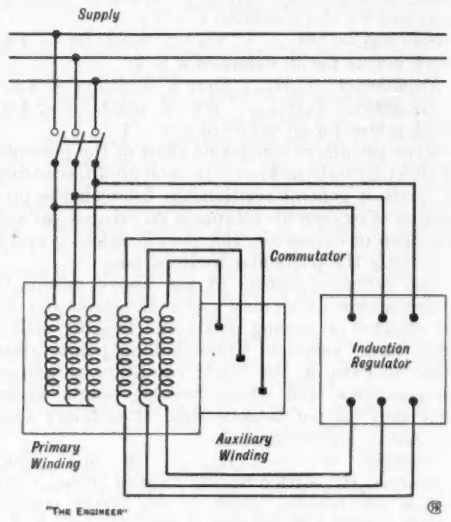


FIG 2—CONNECTIONS OF STATOR-FED VARIABLE SPEED MOTOR

For driving mechanical stokers, both the Schrage and stator-ted types of motor are suitable, and successful installations have been made with both types, generally using totally-enclosed motors. In Fig. 4 is shown one of 23 variable-speed Schrage motors driving chain-grate stokers at Stourport Power Station. All the motors are totally enclosed. The most recent installations consist of 16 motors rated 3·75/1·2 H.P., 1480/480 r.p.m., 400 volts, which are provided with fully automatic control from a combustion regulator. Numerous other stoker motors of this type have been in service for many years, the first installation having been made 16 years ago at Greenwich Power Station. The stator-fed motor with induction regulator is also suitable for stoker drive, where the separate regulator is sometimes an advantage from a control point of view. On a recent installation of six motors, the regulators were coupled in pairs to the combustion control device, so that two motors driving adjacent grates would always run at the same speed. Tests have shown that a similar result can be obtained by using two motors controlled from a single regulator.

Variable-speed motors have also been used for the feed and separator drives in a station burning pulverised fuel. A recent example is the Upper Boat Station of the South Wales Power Company, where Schrage commutator motors rated 1/0·5 H.P., 1000/400 r.p.m. are used for the six feeders, and six motors rated 4/1·6 H.P., 1450/580 r.p.m. for the

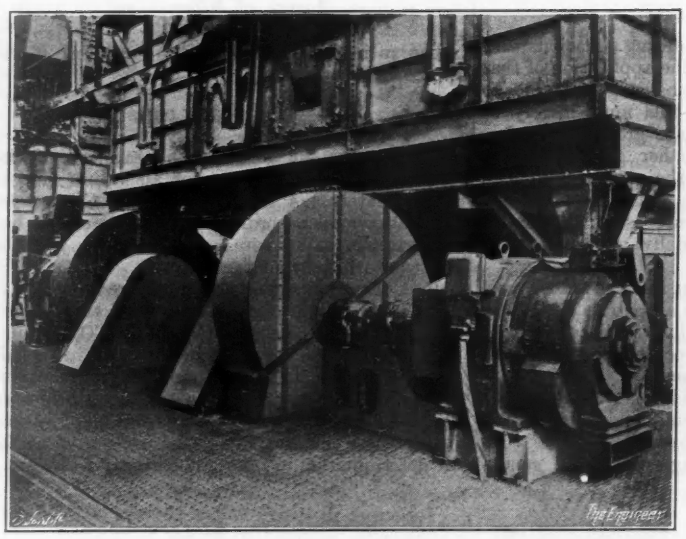


FIG. 3—SCHRAGE MOTOR AT TIR JOHN POWER STATION

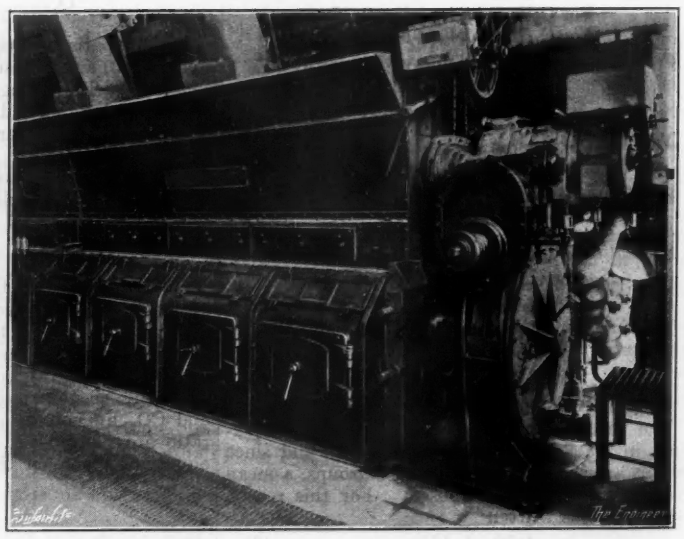


FIG. 4—SCHRAGE MOTOR AT STOURPORT POWER STATION

separators. The six exhauster fans in the same station are driven by variable-speed commutator motors rated 55/25 H.P., 1450/1170 r.p.m. The feeder and separator motors are totally enclosed, and the exhauster-fan motors are ventilated through filters.

The usual drive for boiler feed pumps is a constant-speed motor running at 3000 or 1500 r.p.m., but there are instances where a small range of speed variation is an advantage, especially in the case of high-pressure boilers. For outputs of several hundred horse-power at these high speeds, a commutator motor is not usually possible, but a very satisfactory solution is provided by a Scherbius equipment. Fig. 5 shows such an equipment installed in the power station at the Ford Motor Works, Dagenham, for driving a centrifugal boiler feed pump operating at a pressure of 1500 lb. per square inch. The main slip-ring induction motor, which is rated at 650/400 H.P., 2960/2520 r.p.m., 3000 volts, is controlled by a Scherbius slip regulating set mounted on a platform above the motor, the slip regulator in turn being excited from an A.C. exciter coupled through a skew gear to the non-driving end of the main motor. The actual control of speed is obtained by push-button control of a pilot motor driving the movable brush-gear of the exciter. This arrangement, using a brush-shifting exciter, gives the same fine control as is obtained with the self-contained Schrage motor.

The normal drive for a circulating water pump is a constant-speed motor. Here again, however, variable speed is required in special cases such as, for example, where it is necessary to provide for alternative sources of water supply. For this drive a commutator motor can be used if the power is relatively small, or a Scherbius equipment for larger powers.

Where two alternative speeds are sufficient, a set consisting of two induction motors connected in cascade provides a practicable drive, since the inherent limitations of cascaded motors, namely poor power factor and low pull-out torque at the low speed, which have restricted their application for general purposes, are not serious disadvantages on a pump drive in a power station. A set of this type, which is installed in the Kirkstall Power Station, Leeds, is illustrated in Fig. 6. The output required for this circulating water pump drive is 840/390 H.P., 420/330 r.p.m. The pump normally runs at the lower speed, but a higher speed is necessary for starting in order to set up syphonic action.

Power-house cranes differ little from those in other places. A commutator motor drive is justified where specially fine control is required, as in the case of a crane in a power-station engine room, where accurate control is necessary for maintenance work on steam turbines and generators. An example of this type is the crane in the power station of the St. Anne's Board Mill, Bristol, on which the hoist motion is driven by a Schrage type motor rated 10/1 H.P., 1750/175 r.p.m.

On unloading cranes, where rapid control over a wide range of speeds is the most important requirement, the Schrage motor has been used with good results. In other cases there is an advantage in using a motor with series characteristics. Fig. 7 shows a single-phase variable-speed motor of the repulsion type rated 52 H.P., 600 r.p.m., three of which are installed on the hoist motions of wharf cranes at the Ferrybridge and Thornhill Stations of the Yorkshire Electric Power Company. On the same cranes the slewing and travelling motions are driven by single-phase repulsion motors of 10 H.P. and 20·5 H.P. respectively.

These examples show that there is considerable scope for A.C. commutator machines on power-station auxiliary drives. Careful consideration must be given to the choice of machine and to the method of enclosure, but if suitable precautions are taken, a high standard of reliability with freedom from trouble is obtainable. At the same time, a variable-speed commutator motor can provide the greatest possible efficiency of operation and flexibility of control.

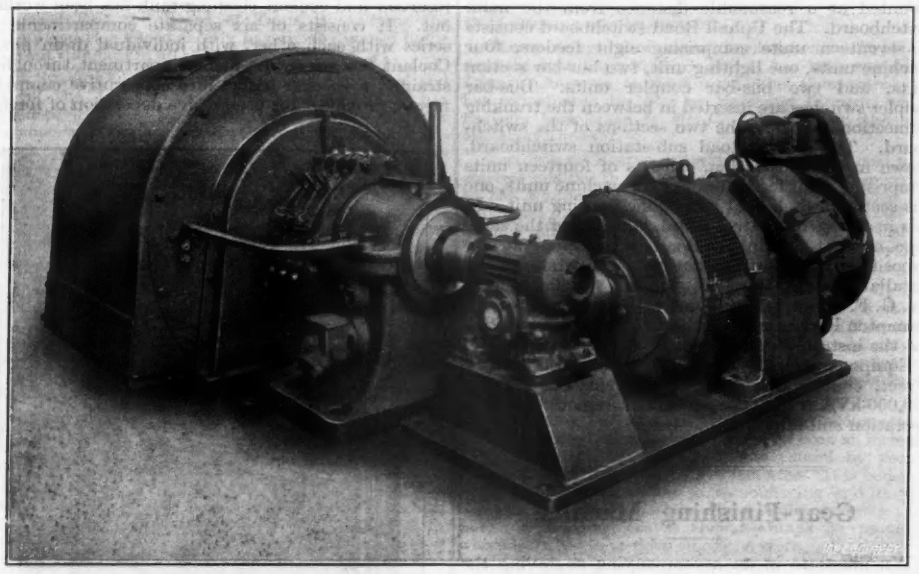


FIG. 5—SLIP-RING MOTOR WITH SCHERBIUS CONTROL

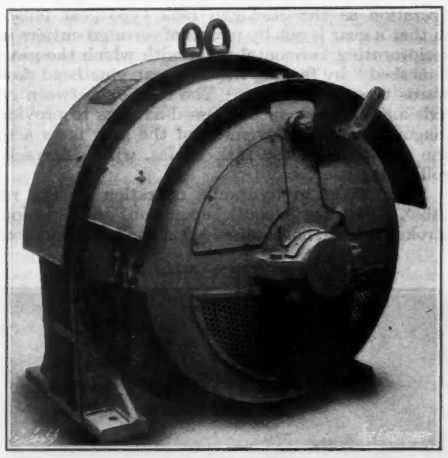


FIG. 7.—SINGLE-PHASE REPULSION ROLLER MOTOR

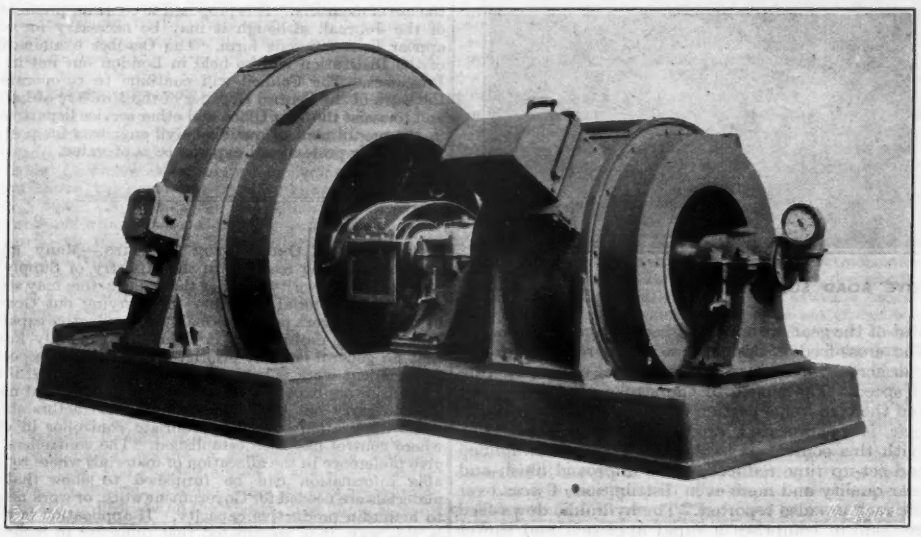


FIG. 6.—MOTORS FOR DRIVING CIRCULATING WATER PUMP

Micromatic Hydrohoner

THE machine illustrated herewith is known as the Micromatic Hydrohoner, and is made by the Micromatic Hone Corporation, of America, for which Gaston E. Marbaix, Ltd., of Humglas House, Carlisle Place, S.W.1, is agent in this country. The Hydrohoner provides a selective, wide range of speed combinations of rotating and reciprocating spindle travel. The relatively high-speed abrasive motion thus produced is combined with a low-speed reciprocating movement of the work, which is chucked or loaded in a fixture and mounted on the hydraulically actuated work table. In the operating cycle the work is moved up automatically to the working position, and the table is slowly reciprocated through its predetermined working stroke. The range of stroke provided on standard machines is:—Spindle, 0in. to ½in.; table, ½in. to 8in. The spindle stroke is readily adjustable by remote control. Expansion and contraction of the abrasive members in the hone body is controlled hydraulically. With an operating cycle (actual honing time) of only a few seconds per piece, for usual applications, high production is easily obtainable, as related to the design and operating efficiency of the work-holding fixtures.

MICRO-HONER

The Hydrohoner uses a form of swash plate action to obtain a very rapid, odd-ratio reciprocating motion of the spindle as related to its rotation. This actuation produces a multi-directional travel path of the abrasive, which is claimed to assure continuous, uniform abrading effort throughout the entire operating cycle. The expansion limit of the tool is predetermined by setting the head adjustment on the nose of the machine spindle. In addition to the above, microscopic increments of expansion or feed adjustment, ranging from 0·00005in. to 0·000125in. on, and according to, the diameter, may be made by quick manual control during the operating cycle, if desired. Accuracy, within a few ten-thousandths of an inch for roundness and straightness, is said to be easily obtainable in production, depending upon the characteristics of the work to be honed. It is claimed that surface smoothness within 5 microinches, root mean square reading, is easily produced in most types of work, and tolerances of 1 to 2 microinches are accomplished in some parts.

Proportionate, continuous feed, or expansion of the stones during each cycle of operation, is maintained by an hydraulic piston, which feeds in relation to stone wear as bore enlargement occurs. The honing

sticks are held rigidly against the bore wall by a controlled, constant pressure, hydraulically actuated. Working pressure is adjustably predetermined by setting the pressure regulator provided with the hydraulic pressure generating and control unit. Pressure application is arranged with remote control, actuated automatically by the table movement.

A single movement of the operating hand lever starts a synchronised cycle of actuations, comprising the following actions:—(1) The table automatically moves, carrying the work from the loading into the honing or working position; the spindle motor starts the rotation and reciprocation of the spindle; the hone is automatically expanded and the actual honing cycle started at the precise time when the work is in the predetermined honing position. A single reverse movement of the operating hand lever causes the stones to contract, and simultaneously stops spindle rotation and reciprocation, and automatically returns the table to the loading position. Another hand lever, arranged for manual operation, provides for short stroking the table, if desired.

The machine is equipped with coolant tank of approximately 20-gallon capacity for single spindle machines. The coolant pump and filter are belt driven by the hydraulic unit motor. All this equipment is contained in the base, arranged with convenient access panels.

Hone bodies are available for every $\frac{1}{32}$in. increase in diameter of bores. All hone bodies are interchangeable on the machine and are fitted with ball retaining mechanism to facilitate quick interchange. Abrasive sticks are mounted inexpensively in simplified stone holders. They are easily and quickly replaced in the hone body. The spindle is of replaceable cartridge design. All moving parts operate in a constant-level self-regulated oil bath. The spindle is mounted in anti-friction bearings and is in balance at all times. Hydraulic pressure is maintained uniformly by floating differential piston construction. All working parts are made of hardened or heat-treated steel. The machine is designed to withstand long, hard service in high production. Spindles are vee belt driven, with various speed pulleys available and interchangeable for any desired speed range.

Electrical Development at Ilford

THE recent modernisation of the Ilford electricity supply distribution affords an example of the trend towards the overhaul of distribution schemes with a view to ensuring adequate and reliable protection. At Ilford the two large sub-stations in Uphall Road and Grove Road have been completely re-equipped. Following the practice adopted at the main distribution station at Ley Street in 1937, truck type switchgear has been installed, and in the case of Uphall Road sub-station duplicate bus-bars have been fitted with off-load selector isolating switches. The switchgear, of Crompton-Parkinson manufacture, has a proved rupturing capacity of 250,000 kVA at 6·6 kV, and additional tests at 6·6 kV and 11 kV were taken in conformity with B.S.S. 116—1937, and to confirm the results of the previous tests.

Owing to the margin of safety of the equipment the whole series of tests was completed without changing the arcing contacts, the oil also being unchanged throughout. At the end of the tests the oil level in the tank was approximately the same as at the beginning. The behaviour of the switch indicated that there was an ample factor of safety at the rated capacity of the circuit breaker. In designing the truck unit care was taken to ensure adequate thermal capacity with the short-circuit rating, and a properly designed structure to withstand short-circuit stress under all conditions of fault operation. The oil switches are fitted with solenoid closing gear actuated from a desk type control board mounted at a reasonable distance from the main switchboard. The Uphall Road switchboard consists of seventeen units comprising eight feeders, four machine units, one lighting unit, two bus-bar section units, and two bus-bar coupler units. Bus-bar coupler switches are inserted in between the trunking connections between the two sections of the switchboard. The Grove Road sub-station switchboard, shown in the illustration, consists of fourteen units comprising eight feeder units, four machine units, one bus section switch, and one public lighting unit. In this instance the control board, which is of the same type as that at Uphall Road, is mounted at the opposite side of the sub-station. The whole of the installation was supplied to the specification of Mr. G. F. Gregory, the Ilford electrical engineer, by Crompton Parkinson, Ltd., of Chelmsford, who carried out the installation work.

Equipment supplied in 1937 for the Ilford, Ley Street, change over comprised twenty-six 6·6-kV, 350,000-kVA truck type units with remote electrical operation and duplicate bus-bars.

6·6-KW SWITCHGEAR AT GROVE ROAD SUB-STATION

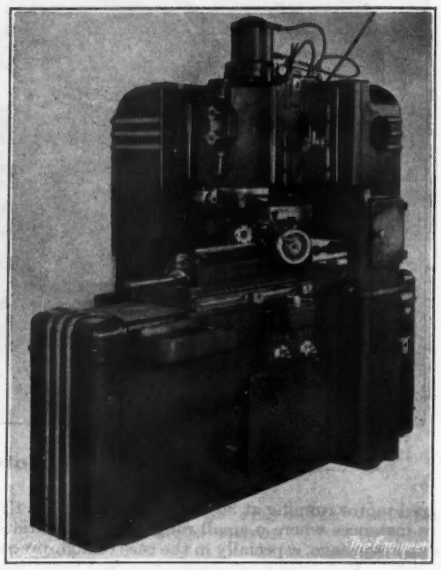
feed of the gear are accomplished by hydraulic means. The cross-feed is designed so as to reciprocate the gear across the rack at a constant but adjustable rate of speed. The length of the stroke across the rack and the transverse portion of the rack over which the gear is reciprocated are also quickly adjustable. With this control, it is claimed, set-up is simplified and set-up time reduced, while improved finish and gear quality and more even distribution of wear over the rack are also reported. The hydraulic down-feed mechanism comprises a rapid approach and slower cutting feed. Cutting feed is adjustable by means of a single valve from 0·0005in. to 0·0025in. per cycle of the table. Automatic stops are provided to stop the down feed when the gear has been properly sized. A dial setting is provided to stop the rack automatically after the desired number of "finishing" strokes. The head then automatically rises through a rapid return, clearing the gear for unloading and reloading. Trip dogs are provided to adjust the travel of the rack.

In the coolant system an interesting combination reservoir and coolant cleaning tank has been worked out. It consists of six separate compartments in series with each other, with individual drain pipes. Coolant flows into the first compartment through a strainer, then over baffles into consecutive compartments, providing for progressive deposition of foreign matter. The fifth compartment is filled with steel wool for final filtering. The development is reported not only to have improved quality of finish, but also to have materially increased tool life. A central lubrication system is provided to oil all vital parts of the machine automatically each time a gear is finished.

Gear-Finishing Machine

WE illustrate in an accompanying engraving the "Michigan 900" gear-finishing machine, which has recently been produced by the Michigan Tool Company, of Detroit, for which Gaston E. Marbaix, Ltd., of 22, Carlisle Place, London, S.W.1, are agents for Europe. This machine will take gears up to 8in. diameter and has a length between centres of 18½in. It is a completely hydraulically operated, heavy-duty, high-production gear finisher, which operates on the well-known crossed axis "shaving" method of cutting. It embodies the same basic principle of operation as the Michigan rack type gear finisher, in that a gear is cut by means of serrated cutters in a reciprocating horizontal rack, with which the gear is "meshed" by feeding the work-carrying head downwards towards the rack. The relation between gear axis and cutter is such (crossed-axis) as to provide a diagonal relative movement of the gear faces across the serrations in the rack blades, while the rack is rolling the gear.

In addition to hydraulic operation of the rack table, providing smooth operation and cushioned stroke reversal, both cross-feed of the head, and down-



GEAR FINISHING MACHINE

Structurally, the new gear finisher is notable for its massive construction. Head gibs are situated directly over the centre of the gear being finished, eliminating any tendency towards "weaving." The cross rail or bridge of the machine is a single piece casting for rigidity. Head and tail stocks are secured by four bolts in hardened and ground ways, eliminating the use of gibs for clamping the stocks, and providing a more solid anchorage.

The machine is driven by a 5 H.P., 1200 r.p.m. electric motor, placed in the base of the machine.

The Institution of Civil Engineers

IT is announced that the Council of the Institution has decided to continue, as far as may be practicable, the work of the Institution from the headquarters building in Great George Street, Westminster, S.W.1. The meetings of the Institution in London will be suspended until further notice, and the Conference on Engineering Education and Training and the Road Engineering Exhibition are postponed indefinitely. The Reading Rooms and Library will be open, and the normal loan service of books available for the use of members. It is proposed to continue publication of the Journal, although it may be necessary for it to appear in a different form. The October examinations of the Institution will be held in London but not in the Provinces. The Council will continue to co-operate in the work of the Central Register of the Ministry of Labour and to assist the War Office and other service departments in the recruitment of qualified civil engineers for posts in which their professional experience is of value.

GOVERNMENT ORDERS FOR SUPPLIES.—Many applications are being received in the Ministry of Supply for certificates of priority in order that contractors may secure supplies of material necessary for carrying out Government work or work needed to maintain productive capacity. The Ministry desires that it should be generally known that no general issue of priority certificates in respect of Government work is yet considered necessary, and if any difficulties are experienced in securing the material necessary to carry out Government work, contractors should make application to the appropriate controller in cases where control has been established. The controllers will give preference in the allocation of materials where reasonable information can be furnished to show that the materials are needed for Government work, or work needed to maintain productive capacity. If application is made in this way, it is anticipated that difficulty in regard to supply of materials for the carrying out of work, will, as a rule, be readily surmounted.

Road and Rail

DINGWALL BY-PASS.—The construction of a 60ft. wide by-pass road at Dingwall in Ross-shire is to be begun at once.

TRAIN LIGHTING.—Since the beginning of the war trains running on the surface lines in the London Transport and a number of other areas have been running without lights during the "black-out" periods. It is now announced that the Board of Trade is studying the problem and it is hoped shortly to provide dimmed lights of a fixed standard in all railway carriages.

BUS SERVICES.—Following the rationing of petrol and fuel oil the London Passenger Transport Board has announced that only three central bus services and four supplementary services on short routes have been withdrawn. Apart from these there will be no withdrawals or alterations of the present services. All the tram, trolleybus, and train services will be maintained.

GOODS TRANSPORT ON TROLLEYBUS ROUTES.—A new type of goods-carrying vehicle which is expected to show great economy in working has been placed upon the streets of Moscow. It is propelled by two power systems, one an ordinary petrol unit and the other electric, taking current from the trolleybus lines of the city. Known as the "trolleycar" it has a capacity of about five tons.

TRANSPORT IN LEICESTER.—It is announced that the replacement of trams by buses is to be stopped in Leicester, and tramway services are not only to be maintained on all routes at their present level, but in some places will be extended and augmented. At the same time buses will cease to operate in the centre of the city and will be used to feed the tram routes from the outlying housing estates.

LOCOMOTIVE CRANK AXLES.—It is reported that the new streamlined two-cylinder Atlantic engines of the Belgian National Railways are being fitted with built-up crank axles. These axles will be in nine pieces having four balanced webs of nickel chrome steel, the cylindrical pieces forming the axles being of heat-treated carbon steel. It is understood that experiments are to be made with webs of chrome molybdenum steel.

ROAD IMPROVEMENT WORKS.—The prevailing emergency conditions have necessitated a delay in work upon several of the important road improvement schemes in this country. Many of the roads involved will be of national importance, and the Ministry of Transport announced some time ago that there is no intention of abandoning the programme unless in certain cases it becomes unavoidable. New schemes are being considered on their merits.

CONCRETE ROAD DURABILITY EXPERIMENTS.—An experimental road was laid in the United States in 1924–25 to determine the merits of three coarse aggregates: gravel, stone and slag. After fifteen years' service under a mixed traffic load the concrete surface containing slag aggregate was in a reasonably good condition. That containing gravel was in a fair condition, scaling having occurred in places, but the surface containing broken stone aggregate required surface treatment.

CLOSED TUBE STATIONS.—The Ministry of Transport announces that certain tube stations, which have had to be closed in London, will be open for traffic as soon as the major works necessary to make these stations immune from flooding have been completed. The protective works are being carried out as speedily as possible, but owing to the difficult nature of the task, in some cases, it may take several weeks before stations can be brought back into service.

RAILWAY DEVIATION IN SOUTH AFRICA.—Particulars of the deviation of the railway line between Cambridge and Queenstown are given in the *South African Engineer and Electrical Review*. This work will shorten the route by sixteen miles and give a reduction of curvature equivalent to thirty-six complete circles. It is being carried out at a cost of about £1,626,000 and will take about five years to complete. The new line will have eleven tunnels, the largest of which will be 3000 feet. All public roads crossing the line will be traversed by bridges or tunnels. Wherever possible concrete bridges are being employed instead of steel bridges.

UNITED STATES RAILWAYS AND WAR.—A recent issue of the *Railway Age* states that the railways of the United States are now in a far worse state to handle the increase in traffic which will be brought about by this war than they were in 1914. It is pointed out that between 1914 and the time the United States entered the war 19 per cent. more freight traffic was carried and, following its entry into the war, there was an increase of 40 per cent. It is considered that over 2400 new locomotives of 75,000 lb. tractive effort and 300,000 new 40-ton freight wagons will be required to give the railways the necessary capacity.

A SUBSTITUTE FOR TRACTOR WHEEL WEIGHTS.—As a substitute for the heavy weights used on tractor wheels the Allis Chalmers Manufacturing Company, in the United States, has developed what are known as "Hydromatic" tyres. According to the *Machinist* these are balloon tyres which, instead of being entirely filled with air, are about three-fourths filled with a freeze-resistant liquid. The remaining space is filled with air, so that the desired pressure can be maintained in the tyre. The liquid is a mixture of 15 per cent. calcium chloride and 85 per cent. water, having a specific gravity of 1·14. This mixture will form a slush at 10 deg. F. above zero (but will not freeze to a solid, even at 20 deg. below zero), and no harm will be done to the tyres even at lower temperatures. The liquid, being heavier than water, supplies the weight formerly provided by means of wheel weights. It is easier to add or remove than the heavy wheel weights formerly used. It is claimed that the liquid tyre ballast results in smoother wheel rotation, better traction, and steadier action in the entire tractor. Furthermore, the weight added inside the tyre necessitates no unsightly projections on the wheels. The liquid is easily pumped through the tyre valve and removed in the same manner. The calcium chloride in the liquid will not harm the casings, tubes, or valves.

Miscellanea

NEW POWER STATION IN FINLAND.—A new power station is to be built at a cost of 90 million marks at Uleaborg, in Finland, on the Merikoski rapids.

CHADWICK PUBLIC LECTURES.—In consequence of the war, it has been decided to postpone, for the present, the Chadwick Public Lectures which were to have been delivered this Autumn. Due notice will be given when the Lectures are to be resumed.

UNITED STEEL COMPANIES DIRECTORATE.—It is announced that Captain R. S. Hilton has been appointed Deputy Chairman of the United Steel Companies. He has relinquished his post as Managing Director, which has now been taken by Mr. C. J. Walsh, the Assistant Managing Director.

DIRECTOR OF MINING SUPPLIES.—In order to deal with matters relating to the maintenance of supplies essential to the working of mines, the Secretary of Mines has appointed Lieut.-Colonel J. A. S. Ritson, Director for Mining Supplies. The principal priority officer will be Mr. W. F. Richardson and he will be assisted by Mr. R. Crawford and Captain P. S. Hay.

A.M.I.E.E. EXAMINATION, NOVEMBER, 1939.—It has been decided to hold the Associate Membership Examination of the Institution of Electrical Engineers on November 28th, 29th and 30th. Should, however, fresh circumstances make it impossible to hold the Examination due notice will be sent to all candidates who have entered, and their examination fees will be refunded.

PREVENTION OF ROOF ACCIDENTS.—An announcement from the Home Office says that there has been an increase in the number of fatal accidents caused by people falling through the glass roofs of factories. It is believed that this increase is due to camouflaging and to the obscuring of lights, and the Home Office suggests that duck or crawling boards should always be provided where work has to be done on fragile roofs.

FIREDAMP EXPLOSION EXTINCTION.—Further developments in a method of making firedamp explosions self-extinguishing, which was described in earlier reports of the Safety in Mines Research Board, are described in the latest report. Research has shown that a mixture of 80 per cent. of common salt, 18 per cent. of French chalk, and 2 per cent. of magnesium carbonate, which is very effective in suppressing coal dust explosions, is more effective than gypsum or slate dust in extinguishing a firedamp explosion. The addition of 10 per cent. of sodium fluoride to slate dust considerably increases its efficacy.

STEEL RESEARCH IN AMERICA.—According to the American Iron and Steel Institute about 10 million dollars is being spent this year by the steel industry of the United States on research into methods of improving its products and the development of new products. It is stated that nearly 2550 chemists, metallurgists, physicists and other trained scientists devote all their time to research in the industry's laboratories, while about 1300 others devote a substantial part of their time to research activities. The number of full-time workers excludes those who are employed in routine technical activities.

DIESEL ENGINE USERS ASSOCIATION.—The Committee of the Diesel Engine Users Association has decided that every effort should be made to carry on the work of the Association as usual, in spite of war conditions. Until further notice the meetings will take place in accordance with the programme already published with the exception that the time of the meetings, at Caxton Hall, Caxton St., Westminster, S.W.1, on the advertised dates, will be at 2.30 p.m. instead of 5 p.m. The first meeting is on Thursday, October 12th, when a Symposium on Running Gear for Diesel Engines will be submitted for discussion.

BRITISH FOUNDRY SCHOOL.—In issuing the diploma pass list for the session 1938–39 the Governing Body of the British Foundry School, with the approval of the Board of Education, announces that it has decided to close the School until further notice. Arrangements for opening the session on September 19th were therefore cancelled. Due notice of reopening will be given. It is also announced that Mr. E. J. Ludlow, whose name appears in the pass list for the session 1938–39, has been awarded the first of the Fellowships recently established by the Worshipful Company of Founders for the purpose of providing further facilities for training to men of outstanding talent.

TAKING SAMPLES FROM DRILL HOLE WALLS.—A useful device for obtaining samples from the walls of drill holes in mines, &c., has been developed in the United States by Messrs. E. G. Leonardon and D. C. McCann. The method consists in firing a bullet into the side of the borehole at a predetermined depth. The bullet consists of a hollow cylinder which serves as the core barrel and is fired by by means of a powder charge. This bullet is attached to the gun barrel and housing by two lengths of wire, and housing in turn is attached to the supporting cable. Thus, by hauling in the cable, the bullet may be pulled from its position in the formation. The powder charge is ignited by an electrically heated wire. By means of a suitable housing, up to 18 bullets may be fired in different horizons before withdrawal. The cores are ¾in. diameter and up to 2½in. long.

CATHODIC PRODUCTION OF HYDROGEN PEROXIDE.—A paper presented recently before the Electrochemical Society of the United States, by Mr. E. Berl, described in detail a new commercial method for the cathodic production of hydrogen peroxide, based on the use of cathodes made wholly or partly of activated carbon of good electric conductivity. The process combines the production at the anode of oxygen (when alkali carbonates or hydroxides are used) or chlorine (when alkali chlorides are decomposed) or persulphates or perborates (when sulphates or borates are used). Diluted alkaline hydrogen peroxide solutions can be produced at current efficiencies of more than 90 per cent. The hydrogen peroxide can be concentrated in the cell so that more than 250 g./L. of hydrogen peroxide are obtained. For the cathodic production of one pound of 30 per cent. hydrogen peroxide in dilute solutions only one-third to a quarter of the electrical energy required by the older anodic processes is said to be necessary.

Air and Water

COMMODORE OF THE UNION CASTLE LINE.—Unless the exigencies of war necessitate his carrying on Captain E. S. Vincent, Commodore of the Union Castle Line and Commander of the "Athlone Castle," is to retire. He has spent 40 of his 48 years at sea with the company, his first permanent command being the "Dromore Castle" in 1920.

TYNE FERRY SERVICE.—The Tyne ferry service between Hebburn-Wallsend and Walker, which has been maintained by Hawthorn, Leslie and Company, Ltd., for over 60 years, and which was to have been closed by the company, is now practically certain to be continued. It is understood that some of the local works have formed a company to continue the service.

ARCTIC PORT FOR FINLAND.—The Helsinki correspondent of *The Times* reports that the Finnish Government has introduced a Bill in the Diet providing for the building of a railway line through northern Lapland to Petsamo, the Finnish ice-free harbour on the Arctic coast. The project is regarded as necessary in view of the disturbance to Finnish shipping in the Baltic caused by the war.

WARSHIP DAMAGED BY A MINE.—On Wednesday, September 20th, the patrol vessel H.M.S. "Kittiwake" struck a mine in the English Channel. Five members of her crew who were missed after the explosion are feared to have been killed and two were injured. The ship returned to harbour for repairs. Of the "Kingfisher" type, this ship was built in 1936 and is of 530 tons, carrying one four-inch and eight small guns.

DREDGING OF THE CLYDE NAVIGATION CHANNEL.—River authorities of the Clyde have been discussing the question of deepening the navigation channel to permit the safe passage to the sea of the large vessels now under construction. The Clyde Navigation Trust has already carried out much deepening and widening, and a survey of the channel showed certain patches not yet dredged. The question is now being considered as to whether it is necessary to carry out deepening at these points.

PROTECTION OF SHIPPING.—In a statement with regard to the naval protection of British shipping the Prime Minister recently pointed out that in the last war, out of some 16,500 ships which were convoyed to and from this country on the Atlantic, only 102 or 0·6 per cent. were sunk by submarine action while on convoy. This system was only applied in 1917, and as it is to be applied immediately, there is no reason to suppose, as soon as it is in working order, that it would prove to be less decisive than twenty years ago.

SHIPBUILDING IN AMERICA.—Since the reconstruction programme for the United States Merchant Marine was introduced, about two years ago, over a hundred ships have been ordered by the United States Maritime Commission. Recent orders include ten C-1 type single screw cargo ships from the Bethlehem Steel Corporation and five from the Western Pipe Steel Company. The latest list issued by the American Bureau of Shipping shows that, of the total number of ships under construction or on order in United States shipyards, 130 of 693,115 tons gross were for classification by the Bureau.

NEW YORK AIRPORT.—An interesting note with regard to the new airport of the city of New York is given in an article in *Flight* entitled "American Methods and Modes," being the impressions of Mr. J. I. Waddington during a visit to the United States. He says: "We passed the much publicised North Beach Airport of New York City, which has so far taken two years to construct, and the date of completion of which seems still to be indefinite. Its layout has provided much criticism, as adequate advice had not been taken from practical flying people. For instance, the new hangars have been built directly beneath the control tower, thereby completely obscuring the view from the latter. The alternatives are, as one humorist suggested, to increase the height of the control tower by 100ft., or to instal television. The airport has been actually a tremendous undertaking, the length of the runways varying from a minimum of 4,400ft. to a maximum of 7,200ft., and as the ground is reclaimed marshland 120ft. piles have had to be driven in for foundation purposes. On the question of runways there seems to be division of opinion as to the relative advantages of concrete and tarmacadam. The disadvantage of the former is that they tend to have sharp edges and, frequently, a considerable "kerb" effect where the neighbouring soil has eroded. They also suffer badly from temperature cracks. On the other hand, the comparatively loose surface of tarmacadam is thrown up on to airscrews."

NATIONAL AIR COMMUNICATION.—It is officially announced by the Ministry of Information that a new organisation styled "National Air Communication" has been established under the Director-General of Civil Aviation in order to enable civil aviation to play its full part in the present emergency. Civil aviation has therefore been put on a war footing. The main objects of the new organisation are to enable civil aviation to continue a number of services; and to meet the essential air communication and transport needs of the Government generally. The organisation came into being immediately on the outbreak of war, and has since been constantly employed. It has carried out many onerous duties. It has flown many thousands of miles transporting key personnel, essential equipment, and stores. Many important officials have been conveyed rapidly to their stations overseas in N.A.C. aircraft, which have successfully completed several notable long-distance flights during the past two weeks. Transatlantic Air Mail Services have been regularly operated and the Empire Air Services are still carrying passengers and mails, although the reduced frequency has made it necessary to suspend the system of carrying all first-class mails without surcharge. National Air Communication, it is stated, was not a hasty improvisation. It was felt that while civil air transport would inevitably be restricted in war, the skilled pilots and equipment available, supplemented by experienced pilots recruited from the Civil Air Guard and the Flying Clubs, could make a most effective contribution to the national effort.

PROJECTED STEAM EQUIPMENT EXHIBITS AT OLYMPIA

(*For description see page* 332)

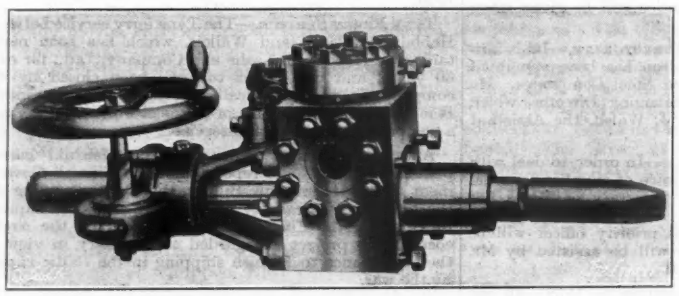


FIG. 71—HAND OPERATED SOOT BLOWER—BABCOCK

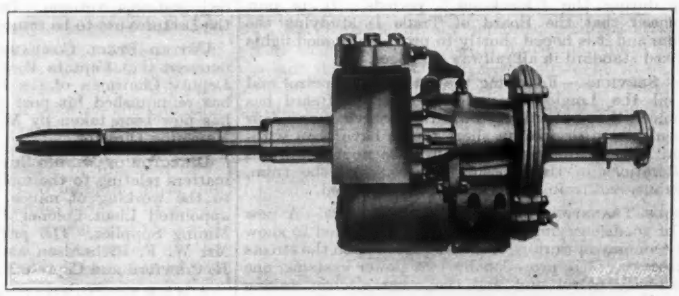


FIG. 72—ELECTRICALLY OPERATED SOOT BLOWER—BABCOCK

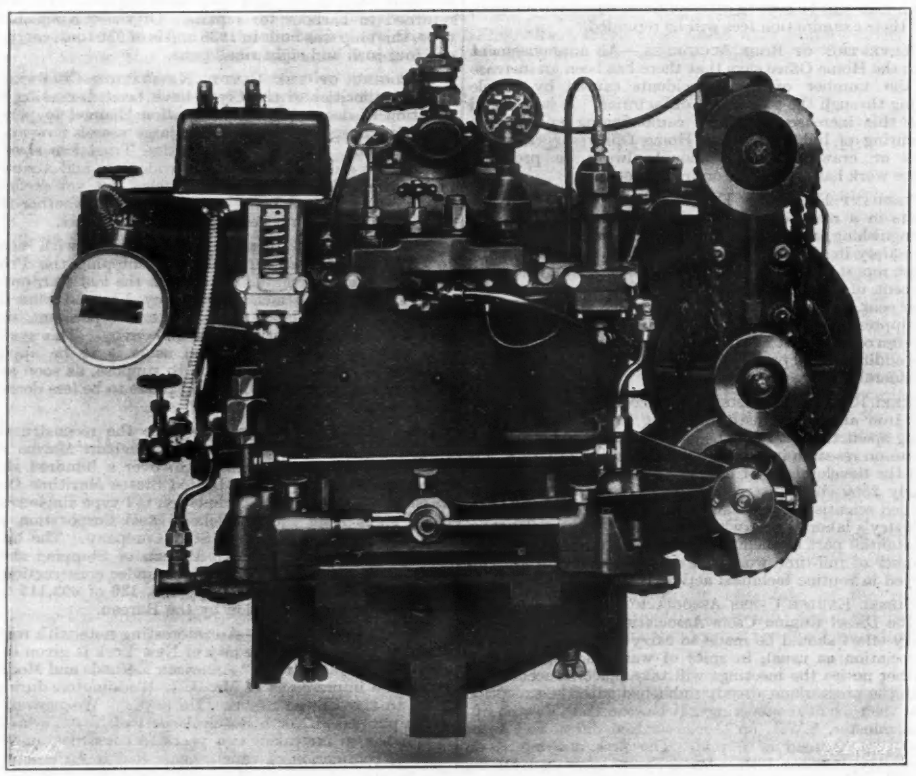


FIG. 73—VAPOR-CLARKSON STEAM GENERATING UNIT—GRESHAM

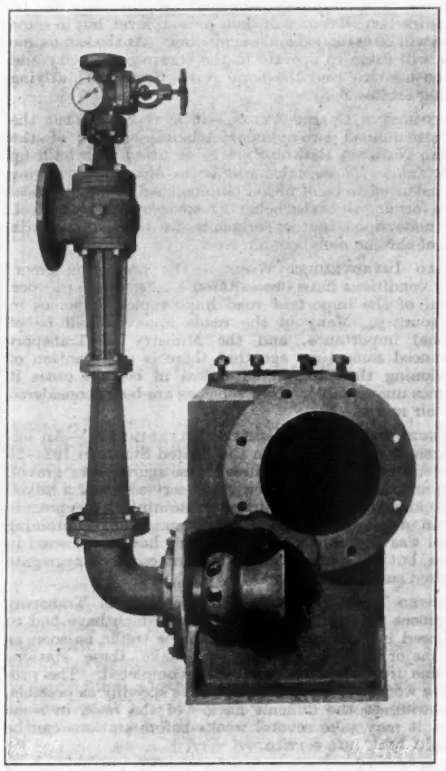


FIG. 74—VACUUM AUGMENTOR—MIRRLEES

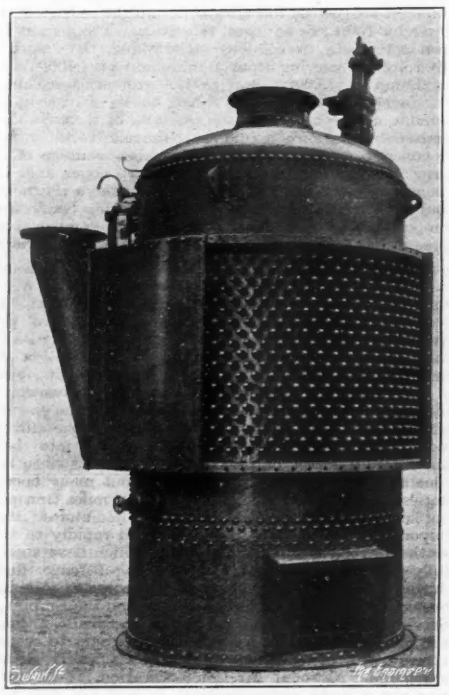


FIG. 75—WASTE HEAT BOILER—CLARKSON

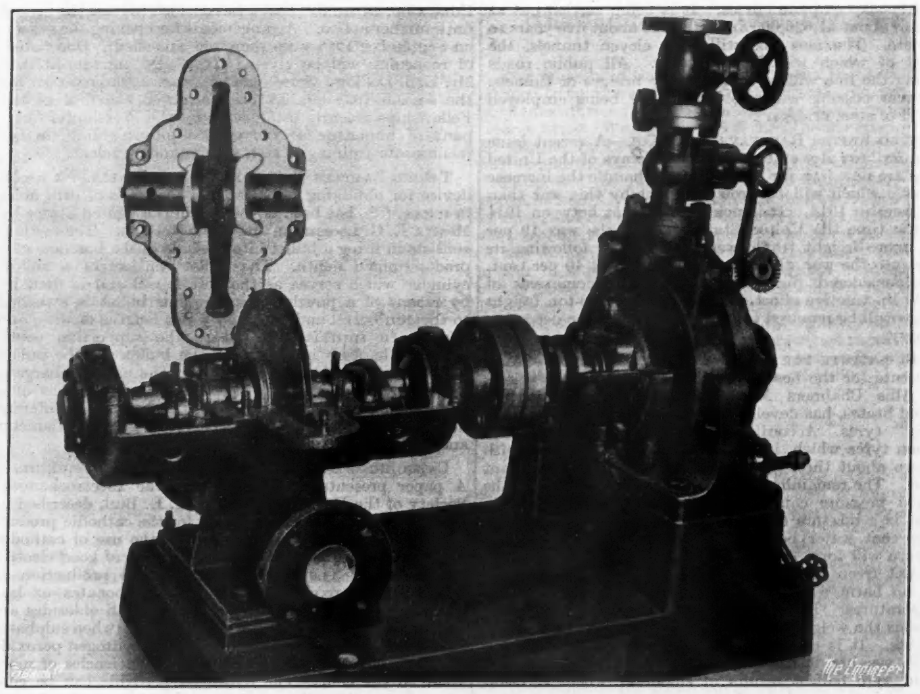


FIG. 76—TURBINE-DRIVEN SHIP'S PUMP—MIRRLEES

The Engineer

SEPTEMBER 29, 1939

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SOCIAL RESPONSIBILITY OF THE ENGINEER

UNDER the title taken for this article Mr. Robert E. Doherty, President of the Carnegie Institute of Technology, gave an address in June last to the Society for the Promotion of Engineering Education. It is printed in the September issue of *Mechanical Engineering*. Mr. Doherty chastises, firmly but mildly, American engineers for not taking more interest in the affairs of their country. They are reminded that America is a democratic state and that it is, therefore, the duty of everyone to understand and play his share in the acts of the government. We are told that the American Engineering Council is withering for lack of support and the reservation with which some engineering societies enter the Engineers' Council for Professional Development is noted. The author regards these two examples as evidence that "the engineering profession, although tending to agree that the engineer's station in society should be higher and his responsibility greater, has not yet reached the point of doing much about it." He remarks that the first named of these two bodies is "the only national medium through which the engineering profession as a whole can serve national welfare as well as its own interests," and that the latter is "the only organisation that is constituted by proper representation to lift the engineering profession on all fronts to the level that it deserves." But, he adds, if the engineering profession is doing less than its duty so is the teaching profession "as a glance at engineering curricula will indicate."

Throughout the address there is an implication that engineers, young and old, in America are so absorbed in their own affairs that they fail to take any interest in social problems, but delegate them to the "social scientist." If we have not found the same defect in this country, where engineers seem to be just as ready to discuss social questions as any one else, we cannot but recognise that the continual growth of specialisation is tending to produce a state of affairs in which everyone is relying upon someone else and refusing to display an interest in what he does not understand. The difficulty here is not lack of interest but lack of organised thought and of the power to exercise an active influence in national questions. No organisation through which the profession of engineering can exercise its power for good in the state exists in this country. The institutions, great as they are in their own spheres, and useful as they may be in the national service on specific occasions, purposely refrain from touching anything that has a political savour and are chary about handling matters that have a social character—as, for example, labour questions. On national issues engineers have to accept the Federation of British Industries as their spokesman, but that Federation, as a whole, is principally interested in commercial and financial matters. Whilst admittedly the breadth of its views—for all manners of industries are included in it—obviates a close and dangerous isolation of any one industry or profession yet it does not attempt to cover that enormous field in which, as the saying goes, engineering impinges upon society. In America the American Engineering Council aimed at fulfilling that function, and we trust that its weakness to which Mr. Doherty alludes may be no more than a passing indisposition brought about by the general conditions in the United States. In France and Germany there are similar bodies, but here there is no organisation that can speak for, and act for, engineering as a whole. We are not without hope that the Engineers Guild, if it can survive the war, may prove to be the embryo of a completely representative Council. Lest a misunderstanding which already appears to be gaining ground should be perpetuated, let us say now and as positively as we can that we do not desire to see the existence of any corporation or body entirely devoted to sectional interests. No organisation can fill its right place in directing national affairs unless its sympathies and its views are wide. What we hold to be required is an organisation which could direct all the resources of engineering for the common good. There is at present great diversity in its ranks. It is split up into a number of different branches—of which civil, mechanical, electrical are the largest—which do not always see eye to eye and which rarely take common action. A body uniting them all is becoming an absolute necessity. But it must be a body with a large mind and a noble conception of its duties. Something far, far greater than the Engineering Joint Council. Representing the most important industry in the world it must co-ordinate the power of that industry, and enable it to speak with a united voice in the affairs of its own country and in international questions.

This vision of a British Engineering Council peers into a future which must of necessity be somewhat remote. Before engineering can perform its rightful duty in helping to mould the policy of nations much must be accomplished. We foresee the time when the engineers of all countries will speak with a single voice, but before that can come about each must organise its own engineers. For a time it is bound to appear that self-interest is the moving force. Until engineers have so unitedthemselves that they constitute a recognised power their counsels will not be listened to. That will undoubtedly involve an insistence on themselves which will seem to be pure selfishness. But through that temporary selfishness recognition will be won, and with recognition power will come and, as Mr. Doherty puts it, the engineer will be "represented on equal footing with other professions and councils of government that might work out intelligent recommendations regarding long-range policy on which legislative bodies or administration might act." In national problems "which involve engineering elements he should have a strong voice in the forming of policy as well as the responsibility for technical plans."

Technical Institutions and the War

ON the outbreak of war, many London businesses were partially or completely transferred to places in the countryside believed to be less vulnerable to enemy aircraft. The majority of the great technical institutions have also, we believe, in accordance with pre-arranged plans transferred their more valuable records and large parts of their staffs to quarters outside central London. All organising and advisory work is being conducted from these country quarters and headquarters buildings in the vulnerable central area are being kept open only to deal with urgent correspondence, to allow members access to libraries and to provide them with a place to meet for private discussion. In this way the Institutions have contrived that in carrying out their very valuable functions they shall be as little hindered as possible by the war. Many of the Institutions, however, have felt themselves reluctantly compelled, at least for the present, to abandon the holding of those technical meetings which are normally arranged to take place during the next few months. The Institution of Civil Engineers has, for instance, cancelled the whole of its proposed programme of meetings for the coming autumn. The Institution of Mechanical Engineers, though it has issued a complete programme to members, has decided upon similar action. Though the Institute of Transport is making plans for the presentation of the Presidential Address next month, it has decided to suspend the remainder of its published programme with the possible exception of the Annual General Meeting in December. The Iron and Steel Institute is to hold its statutory autumn meeting in November, but only for the conduct of ordinary formal business; no papers will be presented. Other Institutions no doubt have been forced by events to take the same kind of action, and the abandonment of meetings is not confined only to the engineering bodies nor only to those societies whose headquarters are in London.

The necessity to abandon meetings arises from causes which to a large extent are at present beyond the control of the Institutions. Until there is some more definite knowledge as to the risks likely to be incurred, the A.R.P. authorities are likely to view with disfavour any proposal for the congregation together in one place of a large group of people constituting particularly valuable units of the population. No doubt means can and will be found to overcome that objection. But the Institutions may well fear that as a result of difficulties of transport and of the large amount of additional work and responsibility falling to the lot of individual members attendances would be small and technical papers of suitable standing hard to come by. Moreover, under present circumstances with reduced staffs acting from country quarters, the mere organisation of a meeting, in peace time imposing little strain on the staff because a matter of routine, may become a more difficult business, especially if black-out regulations require it to be held at an unusual time and an unusual rendezvous. But despite the difficulties, engineers, in common with their Institutions, will deplore the decisions to postpone meetings indefinitely. For one of the main, if not in fact the most important, objects of the great technical institutions is the dissemination of technical information among engineers. That object is best carried into effect by the holding of meetings at which technical papers are presented and discussed. The experience of the few expert in the particular subject is thus made available to all, whilst differences of opinion may be resolved or indication be given of the kind of further research which is likely to result in greater enlightenment. Since the war in which this country is engaged is likely to be won more by the exertions of engineers than by purely military effort alone, it is of prime importance to engineers that their sources of information on technical matters should not be curtailed. Though much of the work upon which engineers will be engaged will be so closely related to military requirements

that secrecy will have to be observed regarding it, there is likely to be no lack of technical subjects suitable for discussion. Any technical advance, even in a field apparently remote from war purposes, may influence general engineering technique and thus aid in the prosecution of the war. Despite the war, many peace-time activities must continue, if only to maintain this country's exports and so make available credits for the purchase of war-time necessities not manufactured in this country. Moreover, sooner or later, peace will return to Europe, and peace-time problems cannot therefore be wholly neglected lest when the war be won the country find itself handicapped in competing in world markets by the existence of better plant and more advanced technique developed in those countries which remained neutral. Though it may be necessary to curtail the number of meetings and to accept short papers provocative of discussion rather than those of very advanced technical quality the time for the preparation of which it may be difficult to spare, engineers, we believe, would hardly tolerate their total abandonment for more than a short period with equanimity.

We have no doubt that it is the intention of the Institutions to begin again to hold meetings at as early a date as possible, and it will be the hope of all engineers that preparations for the resumption will be pressed forward energetically. For that the Institutions should tolerate any lasting interference with one of their more important functions is unthinkable. It would be an unnecessary surrender to difficulties arising out of war conditions. Though its worst effects could be mitigated by the dissemination of information through such journals as THE ENGINEER, the technical press could hardly be expected to undertake completely the task so admirably performed in peace time by the Institutions, and the efficiency with which engineers could play their parts in the war would in consequence be adversely affected by the reduction in the amount of technical information made available to them. For, if the technical meetings of the Institutions are of value in times of peace, they must be of even greater value under the stress of war.

Obituary

CHARLES SCHWAB

MR. CHARLES M. SCHWAB, of the Bethlehem Steel Works, who died in New York on Sept. 18th, was amongst the most remarkable personalities of his country. It would be difficult to find a more convincing example of the "human touch." He was "Charlie" to his workpeople and "Charlie" to thousands of engineers and iron and steel men. He emanated, as it were, human kindness and sympathy, and even those who but knew him for the passing moment, or were merely in his presence, were attracted to him. We recall to this day the astonishing demonstration which followed the presentation of the Bessemer Medal to him by the Iron and Steel Institute in 1928. At the dinner following the presentation he made one of his characteristic speeches—a typical American post-prandial speech in which good fellowship, good advice, and good stories were mingled. Not a person in the room but was moved by it; not a person, we venture to say, who did not feel that "Charlie" was his own intimate friend. We all rose to our feet and cheered him, and afterwards he was surrounded by scores of men, many complete strangers, who wished to touch him, to shake him by the hand, to be able to say afterwards "I knew Charlie Schwab."

We stress this characteristic because there is far more in it than appears upon the surface. There are thousands upon thousands of people who insist that merit is the only thing that should count in the world. But they measure merit by technical ability or business aptitude. They leave out of their account, possibly the greatest factor of all, personality; that indefinable something that gives its owners power through sympathy. Measured by modern standards Schwab was not a great technician. We suspect that his education in the accepted sense was almost negligible. His father kept a livery stable in Williamsburg, Pennsylvania where he was born seventy-seven years ago. The facilities for technical education in America at that day were inconsiderable, but he picked up a little chemistry and learnt to do sums. Opportunities always come to those fitted to take them, but often in strange guise. Young Schwab can hardly have foreseen that his engagement as a grocer's assistant would lead him in but a few years to the biggest salary that had ever been heard of. Captain William Jones the Superintendent of the Carnegie's Edgar Thomson Steel Works was a customer at his shop. He was attracted to "Charlie" and gave him a start in the works. "Charlie" was no more than a boy but he made his mark at once. Even at that age his personality, his power of handling men, and his devotion to work must have raised him far above his fellows. Capt. Jones was killed in an accident at the works and despite his youth Schwab was appointed superintendent in his stead. In 1892, when he was only thirty, the Homestead Steel Works reopened after a strike which is notorious in American industrial history, and he became superintendent, no doubt largely because he could be trusted to deal with the difficult problems in the handling of men that the works presented. He and his employer, Andrew Carnegie, became intimate friends. There was a kindred spirit in the Scotsman and the American; their aims were the same, their outlook the same. Schwab was just the man to keep a vast works moving harmoniously whilst Carnegie attended

CHARLES M. SCHWAB

to business. The pair pulled together harmoniously in their harness. They had their differences, but years after Carnegie's death Schwab would talk affectionately of his "old master." In 1897—remember he was no more than thirty-five then—he succeeded Carnegie as President of the Carnegie Steel Company and a few years later, after the merging of many companies, became President of the United States Steel Trust. That position he held till 1903 when he resigned to become Chairman of the Bethlehem Steel Corporation created by John Fritz, in which he had secured a controlling interest.

At this moment recollection of what Schwab did in the Great War comes back to mind. It was then that his influence was felt far outside his native land. His sympathies were whole-heartedly with the Allies, with Great Britain in particular. He made vast quantities of steel and munitions for this country, quantities so vast that Germany offered to buy him out at any price he liked to name. He told her that there was not enough money in the whole of Europe to change his purpose. He even built submarines for the British navy, but they were assembled in Montreal. When America entered the war the submarine campaign was at its height. New ships were required at least as urgently as munitions. The Emergency Fleet Corporation was set up and against his will Schwab accepted President Wilson's request that he would become its President. He would rather have carried on accelerating munitions production at the Bethlehem works. But President Wilson knew his man. He knew that Schwab's energy and personal force would carry the new Corporation forward; and he was not deceived. Under his impelling force ships were turned out with unbelievable rapidity. A 12,000-ton freighter was launched at San Francisco in twenty-four days from the laying of the keel; a 3500-ton freighter was delivered thirty-four days after she had been laid down; in another yard a hull had scarcely slipped into the water before another keel was laid on the same slip. Such outputs were stunts but Schwab knew their psychological value. They caused the yards to emulate each other. Enthusiasm grew amongst the men and throughout America and reached its height when on July 4th, 1918, Mr. Schwab was able to announce that the corporation had launched its hundredth ship.

Like so many of his fellow countrymen—Henry Ford is another example—Charlie Schwab blended sentiment with shrewd business in a way that seems almost incomprehensible to a people like ours who are rather ashamed of sentiment and seek to hide it even when they feel it. That is not the way with Americans. They are rather proud of it, or if not proud they are not ashamed to show it, and often take an attractive pleasure in it. When Schwab's life is written we have no doubt that examples of this trait in his character will take a prominent place. It is many years ago, and our memory may be at fault in some particulars, but we recall how he told us about the simplicity of his life and his love of his mother, and of her devotion to a little old house in which the family had once lived. The house stood some distance from the country mansion he had built for himself at Loretto, from which it was separated by a wood of trees. To please his mother he had the little house lifted on to a track above the trees and put down upon a site nearer the mansion where she could visit it with comfort. That was typical of the man. There is, if you like, a good deal of sentiment in it, but it was a kindly human action.

It was because he was so capable of such actions, in the simplest way, that "Charlie" was beloved by his workpeople. As a business man he could be hard and shrewd, but underlying it all was a human sympathy and understanding which drew his fellows to him.

SYDNEY EVERSHED

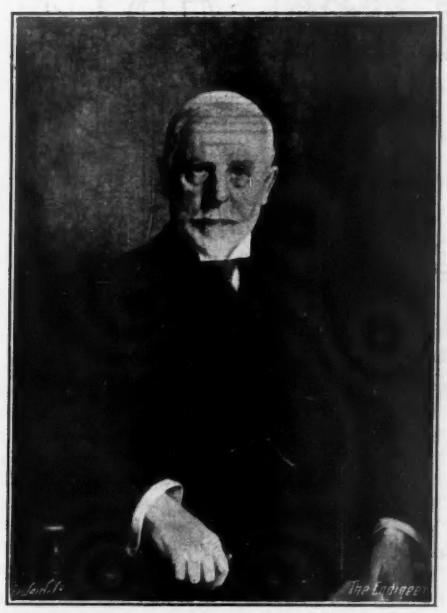
MR. SYDNEY EVERSHED who, until recently, was chairman of the directors of Evershed and Vignoles, Ltd., died suddenly on September 18th, at the age of 82. His work on instruments is well known and appreciated throughout the electrical industry, in which his portable insulation testing sets have proved to be a great boon. He was privately educated and, according to accounts, never passed an examination nor even attempted to do so. At an early age he began to study electricity and magnetism, physics and elementary mathematics. Although he was originally apprenticed to a London optician, his natural bent was essentially electrical. Mr. Evershed became associated with the firm of Goolden and Trotter, and in 1886 was appointed manager. In the previous year he had designed a convenient form of moving iron measuring instrument, constructing the first model with his own hands and winding it as a voltmeter.

This small electrical instrument factory at Westminster, which at the time employed six workmen and a technical staff of two persons, was the cradle of the firm of Evershed and Vignoles as it exists to-day. About 1888, Mr. A. P. Trotter, who was later electrical advisor to the Board of Trade, retired from partnership in the firm, and the late Mr. Ll. B. Atkinson took his place, the firm becoming known as W. T. Goolden and Co. This firm was succeeded by Easton, Anderson and Goolden, and in 1894 when the instrument department was purchased by Mr. Evershed and Mr. Vignoles and some of their friends, the present company of Evershed and Vignoles, Ltd., came into existence. Among those associated with this new development was Professor Ayrton, the first chairman. The business was first carried on at Woodfield Road Works, Harrow Road, but in 1903 land was purchased and a factory was erected at the present site in Acton Lane, Chiswick. It was Mr. Evershed who realised soon after producing his moving iron ammeter that it was essential that the insulation of electrical plant and apparatus should be tested at not less than the working pressure, and that a direct reading instrument should be available for that purpose. Accordingly, he introduced in 1889 his portable ohm-meter and hand generator, and from that date the measurement of insulation resistance ceased to be a laboratory operation with a spot of light.

Although the Evershed method of testing insula-

tion dates from the year mentioned, it was not until 1903 when he completed his invention that it became possible to combine the ohm-meter and generator in one box without magnetic interference. At the same time the word "Megger" was coined and registered as a trade mark, and the moving coil ohm-meter with its hand generator came into being as the "Megger" testing set. Since the introduction of the first set, direct reading instruments have been developed for the whole range of resistance measurements from one millionth of an ohm to ten million ohms.

In 1893, Mr. Evershed invented, in conjunction with Mr. A. E. G. Richards of the Royal Corps of Naval Constructors, a system of electrical communication for use on board ship, the invention being based on an entirely new telegraphic principle. It was first applied as a helm indicator, and installed on H.M.S. "Narcissus," and since then the Evershed helm indicator has been in general use throughout the British Navy. There are other possible uses of the instrument which, as a result of improvements in the precision of working, is now widely used. Mr. Evershed's original direct reading ammeter was the forerunner of many types of switchboard and portable indicating and recording instruments made by the company to-day, and the principle of the moving



SYDNEY EVERSHED

iron instrument is still used by the company, and has been adopted by at least one of its prominent foreign competitors.

In 1886, Mr. Evershed was elected an Associate of the Society of Telegraph Engineers, now the Institution of Electrical Engineers, and was elected a member of the Institution in 1903. From the first he was an active member, taking part in discussions at meetings and occasionally reading a paper descriptive of some research on which he had been engaged. Of his more important papers, one on "Insulation Resistance" was the outcome of a prolonged investigation carried out at his company's works. More recently, he contributed two papers on permanent magnets, adjuncts which although indispensable in the electrical industry had previously received little attention. The first paper disclosed the scientific basis underlying the design and performance of permanent magnets, matters which until then had been quite unknown. The second dealt with the properties and defects of magnet steels and explained the modifications required in steelworks methods in order to avoid the more serious defects. The publication of these magnetic researches has been of great benefit to all who are concerned with permanent magnets, including the manufacturers of magnet steels who had previously been working in the dark.

At intervals, Mr. Evershed was elected a member of the Council of the Institution of Electrical Engineers, his aggregate period of service in that capacity amounting to thirteen years, including two terms as Vice-President. It was during his year of office as Chairman of the General Purposes Committee that he presented Mr. Harcourt's portrait of Faraday to the Institution, the first of many portraits of pioneers of electrical engineering that now hang in the Institution's lecture theatre.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ELECTRICALLY DRIVEN GRAVEL PUMPS

SIR,—We were interested to read in your issue of August 18th an article on a gravel pump pontoon, which is described as an unusual application of an electric motor in gaining gravel from a flooded pit. From the description so published there seems to us to be nothing novel or unusual. My firm has been building such pontoons for the last 40 years and in 1904 supplied a fixed gravel pump, electrically driven, to pump China clay sands and the large amount of gravel or granite found in these deposits. The plant was fixed on concrete foundations, but when I was serving my apprenticeship in 1891/5 at Gwynnes, we made several 4in. or 5in. gravel pumps in pontoons driven by D.C. Motors. In 1910 Gwynnes sold, erected, and set to work a 10in. gravel pump, direct coupled to a 3-phase slip ring motor installed in a pontoon. This was at Pontevedra in Northern Spain. It dredged gravel from the river bed and deposited it ashore to make embankments with roads on the top. The individual who set this plant to work was Mr. H. H. Humphreys, who is now one of our Directors. Electrically driven pontoon gravel dredgers became general practice in 1919 and we have over 200 sets at work at the present moment, varying in size from 6in. to 24in. diameter of discharge.

W. A. TRITTON,
for Gwynnes Pumps, Ltd.

THE F.B.I. IN WARTIME

SIR,—In the last three years a gigantic effort in organisation has taken place; the forces of industry have been mobilised for the production of modern armaments and, at the same time, the vital needs of Britain's export trade have been safeguarded.

Britain, as we know, is prepared for a three years' war. This preparation involves not only the steady working out of the defence programme and the production of munitions, but the no less important claims of the nation's civil needs and of our markets overseas.

The F.B.I., on its side, will do everything in its power to ensure that Britain's export trade receives the fullest possible consideration, subject to the requirements of the fighting services, and, in particular, I would point out that machinery has been set up by the Federation to ensure that export inquiries received by firms unable at the moment to carry them out can be passed on to firms able to do so.

GUY LOCOCK,
Director.

Sixty Years Ago

A FLOATING FIGHTING ISLAND

IN our issue of October 3rd, 1879, we reported the existence of a strong rumour to the effect that John Elder and Company had received from the Russian Government an order for an armour-plated warship 500ft. in length, with a displacement of 17,000 tons, and equipped with engines indicating 10,000 horse power. If the average draught was taken at 22ft. we estimated that the beam of the ship would be about 75ft. She would, we said, bear little resemblance to an ordinary ship. Her upper deck would be flatly curved, rising from the water's edge to the middle like the upper shell of a tortoise. She would in fact resemble a floating island up whose sloping back the waves would wash. Her armament, it was surmised, might consist of six or eight 100-ton guns together with torpedo equipment. It was understood that the design of the ship was the work of Admiral Popoff the designer of the circular ironclads or "cyclads." Russia possessed two of these curious warships but it had been established that they possessed little warlike value. The new "floating island" warship was, however, in our view, likely to prove a most important new departure in naval architecture. To sink such a vessel by ramming would be very difficult because with her enormous beam she admitted of being subdivided into innumerable compartments. With her deck sloping up from the water's edge at an angle of about 35 deg. armour 4in. or even less in thickness would set horizontal fire at defiance. She would only have to fear vertical fire and torpedoes. She could, we argued, steam up the Thames and do as she pleased in spite of every means of defence except torpedoes. No doubt the design called for a sacrifice of speed but speed in a ship which could set her foes at defiance was of secondary importance. In order to attack her by means of plunging fire one of our old three-deckers would be better able to cope with her than any ironclad which we had. It was impossible to shut our eyes to the fact that in the new vessel Russia was likely to possess a fighting ship more powerful than any other in the world. The only weak point in the design was the fact that the guns would have to be fought near the water-level, with the result that they might be swamped. Her cost would be colossal but it was almost if not quite certain that she would be well worth the money spent on her. Our own Government, we urged, would do well to consider the propriety of building a similar ship. We had already taken a step in that direction in the "Polyphemus," a comparatively small craft provided with an armoured tortoise deck and depending for her offensive power not on guns but on her ram and torpedoes. There was good reason to believe that the "Polyphemus" was the only ship in the world which could give a good account of herself if engaged by the new Russian vessel.

Literature

SHORT NOTICES

Boiler Feed Water Treatment. Second Edition. By F. J. Matthews, B.Sc., London: Hutchinson's Scientific and Technical Publications, Paternoster House, E.C.4. Price 12s. 6d. net.—Since the first edition of this book was published some three years ago the continued research into the subject of feed water treatment has brought about improvements in earlier technique. In the preparation of this edition the author has taken the opportunity to revise, enlarge and bring up to date certain sections. In the first section of the book dealing with scale formation, details of the Budenheim phosphate treatment are given and particulars of hydrogen or carbonaceous zeolites and the de-mineralising of zeolites have been added. Much information has also been included on scale formation in cooling water systems and in economisers. The sections on corrosion; foaming and priming; and analysis and routine testing have also received careful attention and the appendix now includes useful conversion tables and a summary of recommended practices with a test for scale deposition. Like the previous edition the book is written in a simple and concise manner which will make it a valuable addition to the Libraries of the considerable number of engineers and others particularly concerned with the subject of feed water treatment.

The Gasoline Automobile. By ELLIOT AND CONSOLIVER. 5th Edition. London: McGraw-Hill Publishing Co., Ltd. 1939. Price 24s.

THE first edition of this book was published in 1915. The primary objective of the work is to form a text-book for the teaching and study of the fundamental principles and ideas upon which modern motor vehicles are designed, constructed, and operated. In the original edition the book had a descriptive and informative nature likely to appeal to people to whom cars were at that time a novel mechanism. Now, however, that the vehicle has become familiar and that the general principle of its operation are known even by children, who have not attained sufficient age to drive it, the book has been converted into a treatise on principles and on those fundamental considerations which must be mastered before the operation of the vehicle can be properly understood. In this latest edition considerable material relating to the oil engine has been worked into the text. New material on tractors and on automatic transmissions has also been added and the various sections of the book have been revised with the help of a number of authorities and in consultation with manufacturers. The vehicles and mechanisms described in the book are almost entirely of American origin.

A Text Book of Heat. Part I. By H. S. Allen, M.A., D.Sc. and R. S. Maxwell, M.A., D.Sc. London: Macmillan and Co., Ltd., St. Martin's St., W.C.2. Price 10s. net.—This is the first of two volumes and is mainly of a descriptive and experimental nature. In it the notation of the calculus is introduced and explained but the mathematical treatment has been kept as simple as possible. The book opens with a historical introduction which includes brief biographical notes on a number of the distinguished workers in the subject. Following sections deal in detail with temperature and its measurement; the expansion of solids, liquids and gases; calorimetry; the change of state solid–liquid and liquid–vapour; atomic and molecular theory; the kinetic theory and behaviour of gases; work done by a gas and the liquefaction of gases; transference of heat; thermal conductivity and radiation; the earth's atmosphere and water vapour in the atmosphere; and thermal units and dimensions. Each chapter contains appropriate diagrams and concludes with a questionaire, the answers to which are given at the end of the book.

Projected Exhibits at Olympia

No. III

(*Continued from page* 313, *Sept.* 22*nd*)

BELOW we continue our description of some of the exhibits which were to have been shown at the Engineering and Marine Exhibition at Olympia, London, the holding of which has had to be postponed on account of the war.

GRESHAM AND CRAVEN, LTD.

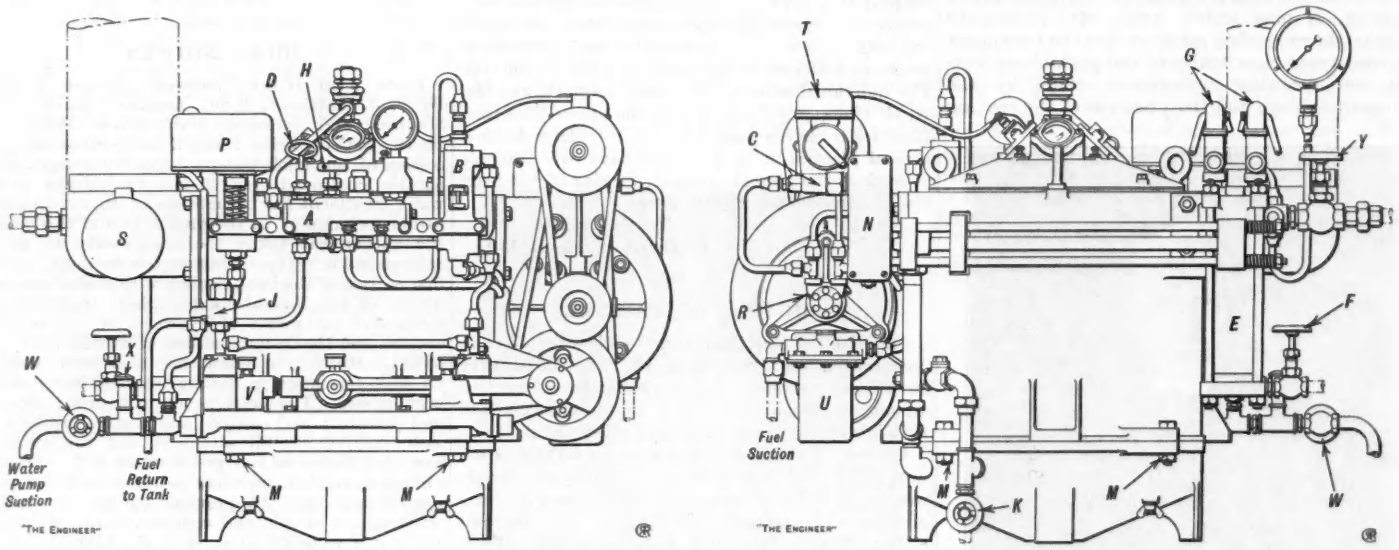
A most interesting exhibit prepared by Gresham and Craven, Ltd., Ordsall Lane, Salford, 5, Manchester, was a new type of small self-contained steam generating unit. The arrangement, known as the "Vapor-Clarkson" generator, is being manufactured under licence from the American patentees at the firm's Manchester works. Designed for outputs of steam of up to 300 lb. per hour at pressures up to 200 lb. per square inch, with or without superheat, the units are suitable for a wide variety of applications, such as the heating of vehicles, vessels, buildings, and factories, or providing steam for industrial purposes, such as the heating of asphalt or oil containers. When adjusted to give superheated steam, it has many uses for drying, cleaning, sterilising, cleaning the façades and floors of buildings, &c. Alternatively, it can be arranged to give high temperature liquid sprays for cleaning locomotives, rolling stock, for gas decontamination, and to provide sprays and emulsions for paint removal, or machinery protection.

The generator, shown in Fig. 73, on page 328, is automatically oil fired and can be driven by a small electric motor or a petrol engine. A noteworthy point is that the overall dimensions of the unit are only 36in. by 24in., with a height of 28in. to the base of the chimney, excluding the driving motor, which can be mounted over the machine if required. Furthermore, the weight of the complete unit with motor and control panel is only 580 lb., while a special lightweight unit constructed where possible in Alpax aluminium alloy is estimated to weigh but 400 lb. It is therefore extremely compact, and has a low weight in relation to its output of steam.

Numerous types of unit, all of the basic standard construction, are available. For example, they may be stationary or portable, with or without tanks for fuel and oil, or trailer units on a two-wheeled chassis. Furthermore, the units can be supplied for continuous operation, for fully automatic operation or automatic operation with a variable output. In the first case, namely, continuous operation, the electric motor or internal combustion engine runs continuously, until it is manually shut down. If the demand for steam is reduced the fuel and oil is by-passed automatically. With fully automatic operation an electric control panel is provided and the set works without manual attention, being controlled by the pressure and temperature conditions of the supply. In the third case a variable output is obtained by the incorporation of a selector switch on the control panel, which enables manual selection of the output rate to be obtained.

In the drawing reproduced in Fig. 78 a sectional diagram of the generator is shown, and side and end elevations are reproduced in Fig. 77. The generator is of the forced circulation type, the water circulating through a staggered coil assembly. This coil is stated to be properly compensated for expansion and designed to split into narrow films the combustion gases, which, of course, flow in the opposite direction to the flow of water in the coils. As shown in the drawings, the coil, base and top plate form an independent assembly, and can readily be withdrawn downwards for inspection or cleaning. Fuel is sprayed into the top of the generator, as shown in the sectional view, and is ignited by a sparking plug. A single motor operates the feed water pump, the magneto for ignition, and a blower for combustion air. Thus the fuel supplied to the oil burner is automatically regulated in relation to the amount of water circulated through the coils and to the amount of air delivered for combustion. In this way the output is variable from 100 lb. to 300 lb. per hour. The maximum power required for the driving motor is stated to be ½ H.P. and the evaporation is claimed to be 10 lb. to 12 lb. of steam per lb. of oil fired. The amount of superheat can be controlled up to about 600 deg. Fah. The diagram reproduced in Fig. 78 makes clear the arrangement of the steam and water circulations. With it and the legend under Fig. 77 the operation of the unit will be clear.

In favour of this type of generator, Gresham and Craven, Ltd., point out that there are no "stand-by" losses, as it can be started or stopped quickly and steam at full pressure is raised in about three minutes. In addition, no running attendance is necessary, as it is operated by means of switches or push buttons. Control is very simple, there being only a selective switch for predetermining the output of the machine on starting up. No other controls are fitted, with the exception of an "overheat" and "no-fire" safety reset switch button, which operates in case of either emergency. Various automatic arrangements are provided for ensuring safe operation. In the event of a failure of the water supply, the burner will not start, or, if burning, is extinguished. An automatic superheat control maintains the quantity and pressure of the fuel and shuts down the burner when the desired superheat is attained. On cooling down, the burner automatically restarts. A pressure control shuts the whole set down when the required pressure is attained, and automatically restarts it when the pressure drops. If there should be a failure of ignition or fuel supply at starting, the whole set is shut down, and the "no-fire" switch button requires manual resetting, thus ensuring that the cause of the trouble is investigated. Similarly, overheating due to any cause shuts down the set, and the switch button requires resetting.



A.—Oil Manifold.
B.—Oil By-pass Control (Water Operated).
C.—Super-Heater Oil By-pass.
D.—Oil Metering Key.
E.—Separator and Collector.
F.—Separator Blow Down Valve.
G.—Safety Valve.
H.—Main Oil Valve.
J.—Water Relief Valve.
K.—Coil Blow Down Valve.
M.—Base Bolts.
N.—Superheater Control Mechanism.
P.—Pressure Switch.
R.—Oil Pump.
S.—Stack Switch.
T.—Ignition Magneto.
U.—Water Pump.
V.—Oil Filter.
W.—Suction Valve.
X.—Washing Branch and Cap.
Y.—Main Steam Valve.

FIG. 77—VAPOR-CLARKSON STEAM GENERATING UNIT—GRESHAM

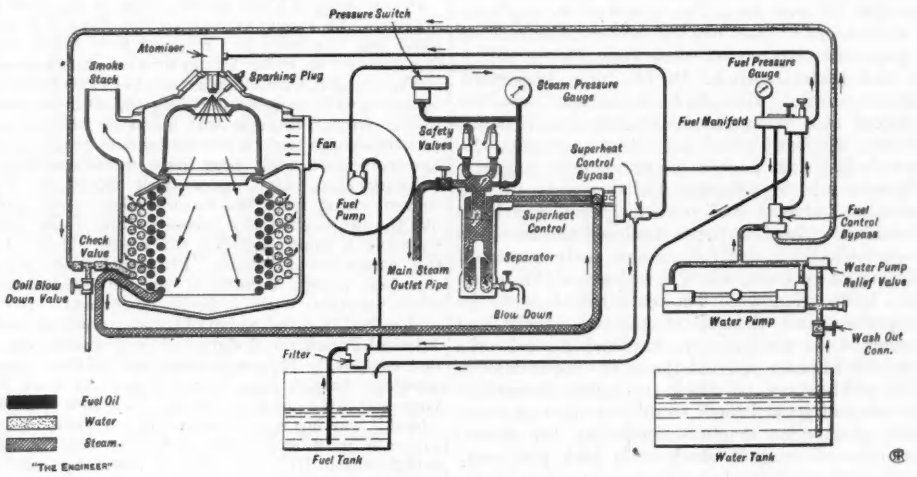


FIG. 78—DIAGRAMMATIC SECTION OF GENERATOR

BABCOCK AND WILCOX, LTD.

Amongst the exhibits prepared by Babcock and Wilcox, Ltd., of Babcock House, Farringdon Street, London, E.C.4, we illustrate a new product, a single-nozzle retractable soot blower, manufac-

tured by the firm. In Figs. 71 and 72, on page 328, hand and electrically operated blowers respectively of this design are shown, and the action is made clear in the accompanying drawing, Fig. 79, showing the hand-operated blower.

Referring to Fig. 79, when the master steam valve is opened steam is admitted into the space A above the blower valve B. The steam leaks through a small orifice in the piston C into the space D. The rotation of the operating gears is transmitted by a sliding key to the steam spindle, which has cut on it a screw thread engaging a nut. The spindle, which is thereby rotated all the time, advances into the operating position until the nozzle is clear of the boiler wall, and a cam E attached to the spindle engages a roller and raises a plunger upwards, forcing open the pilot valve F. Steam in the space D is thereby allowed to exhaust through pipe G to atmosphere, and the steam pressure underneath the piston C compresses the main spring, allowing the valve B to open and admit

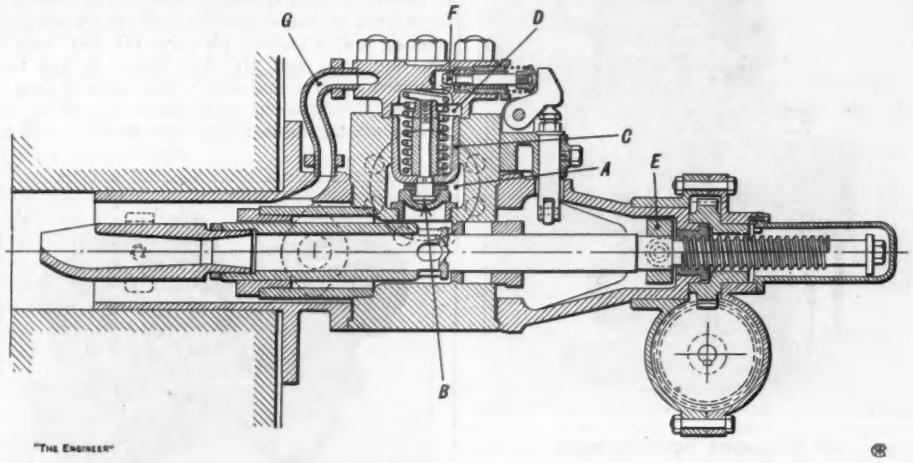


FIG. 79—SINGLE-NOZZLE SOOT BLOWER—BABCOCK

steam to the hollow steam spindle and through the nozzle. The pilot valve is kept open by the cam over the required angle of sweep of the steam jet from the nozzle, after which it is closed by the roller and plunger being released by the cam. As soon as the pilot valve is closed steam pressure builds up in the space D, causing the valve B to close. This action completes the forward blowing motion.. On reversing the direction of rotation the blowing operations occur on the reverse action whilst the cam engages the roller, and continued movement carries the steam spindle and nozzle backwards, withdrawing them inside the boiler wall until the starting position has again been reached.

Several advantages are claimed for the design, amongst which may be mentioned that the poppet valve gives a quick-opening action and avoids steam leakage in the shut position, and also the pilot operation of the poppet valve makes for easy operation of the blower. No lubrication is required for the moving parts under steam pressure, and we are informed that the forged steel body is suitable for boiler pressures up to 850 lb. per square inch without the need for reducing valves. As described above, revolving the hand wheel in the forward direction advances the blower to the operating position and admits steam to the nozzle, whereupon the nozzle blows steam through a predetermined arc. An indicator fitted adjacent to the hand wheel shows the position of the nozzle during the operation. Furthermore, the blower spindle and nozzle can easily be withdrawn from the body without breaking steam connections.

We are informed that the conversion of a hand blower to an electrically operated blower can readily be carried out by uncoupling the hand gear and replacing it by a new gear case and electric motor, all the other parts being interchangeable. Advantages claimed for electrically operated blowers are that with automatic blowing there is the assurance that all the blowers fitted are operated. Every blower is revolved at a constant rate, giving uniform cleaning to the heating surface over which it sweeps. In addition, the correct sequence in operating a series of blowers can be fixed, thus carrying the dust forward with the flow of gases. Finally, no special operators are required, for the boiler operator can readily attend to automatic blowers.

Other exhibits would have included small castings exemplifying the work of the company's steel foundry at Renfrew, and Babcock-Howden swing-out pattern oil burners suitable for installation on cylindrical boiler furnaces, such as recently fitted to the steamship "Llandovery Castle" and other ships. Lockheed-Babcock boiler damper controls, comprising isolating and regulating controls, operated by a hand pump, were also prepared. We hope to make reference to this control gear and gear operated by a motor-driven pump to have been shown by Automotive Products, Ltd., in another article in this series.

An exhibit of much interest arranged by Babcock and Wilcox, Ltd., was a mill for pulverised fuel firing. This machine was shown on the occasion of the British Industries Fair at Birmingham, held in February of this year, and was fully described in these columns. It will be recalled that the design employs a row of balls guided in tracks for the pulverising action, claimed to give low power consumption and fine grinding.

Babcock and Wilcox subsidiary companies include the Calorizing Corporation of Great Britain, Ltd., which would have shown manufactures in "Calorized" mild steel and "Calmet" nickel-chrome heat-resisting alloy, and the Clarkson Thimble Tube Boiler Company, Ltd., whose products are dealt with in a separate section.

NEWMAN MOTORS

This firm, whose works are at Yate, Bristol, manufactures various sizes of totally enclosed surface cooled squirrel-cage motors and component parts. The totally enclosed design is standard throughout the entire range from ¼ to 15 H.P. These machines are suitable for almost any application, apart from flameproof and submersible requirements, and are independent of adverse working conditions, such as dirty surroundings, polluted or moist atmo-

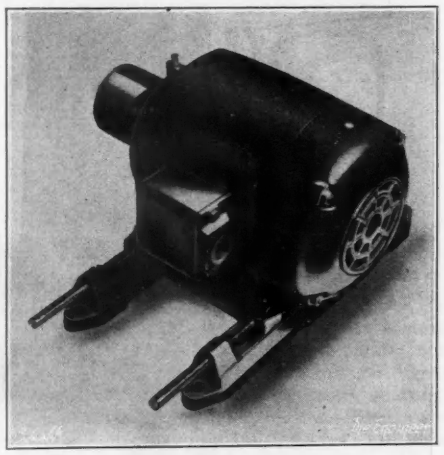


FIG. 80—SQUIRREL-CAGE MOTOR—NEWMAN

sphere, &c. They develop a high starting torque. Although they are totally enclosed machines, the dimensions are said to be slightly less than those of open type or protected machines of equal rating. The motors are supplied with feet for slide rail mounting (Fig. 80) or with flanges for built-on applications. To facilitate the connections of leads and the insertion of the conduit pipe, the terminal box is cast in two parts. In the rotor (Fig. 81) no rivets or bolts are used to secure the laminations and no short-circuiting rings are employed.

The stator slots are insulated with a sheet of micanite, Empire cloth, and leatheroid. Stator coils are wound on multiple formers and there are few joints. To avoid damage when assembling the coils into the slots no hammers or mallets are used. An "envelope" of substantial insulating materials surrounds the coils, making a strong job, and when finally impregnated the assembly is practically proof against breakdown under severe conditions. Before dispatch from the works the

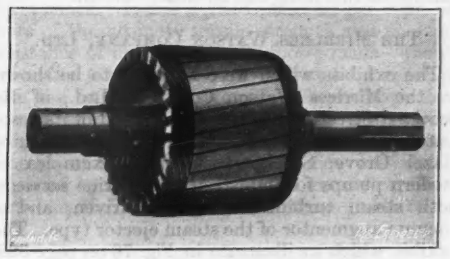


FIG. 81—SQUIRREL-CAGE ROTOR—NEWMAN

machines are tested to ensure that they fully comply with the British Standard specification.

THE CLARKSON THIMBLE TUBE BOILER COMPANY, LTD.

The Clarkson Thimble Tube Boiler Company, Ltd., associated company of Babcock and Wilcox, Ltd., would have shown a one-sixth scale model of the company's latest concentric com posite boiler, which was specially made for the Engineering and Marine Exhibition in order to demonstrate the advantages of this well-proved design. Several boilers of this type are already in use and others are in course of construction. In the model, parts of the casing have been removed to expose the new design of outer thimble

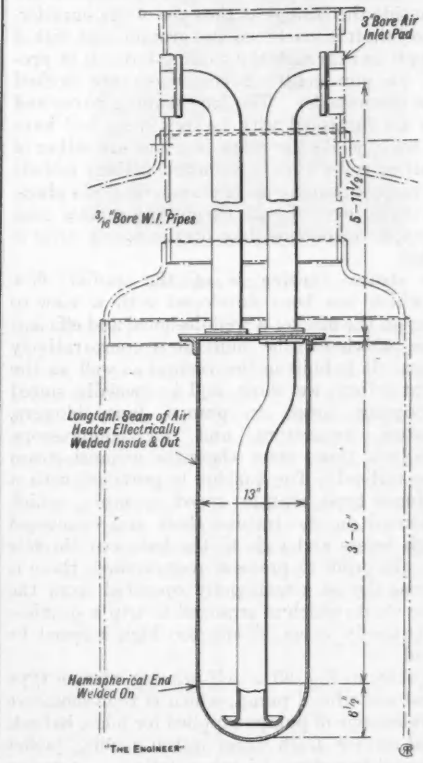


FIG. 82—AIR-HEATER—CLARKSON

tubes which are used for the recovery of waste heat from the exhaust gases. The manhole covers are also removed, so that the easy access given to all wet surfaces is shown. The actual boiler is illustrated on page 328. It has a diameter of 7ft. 6in. with a total height of 13ft., and the design which has been adopted provides for the raising of steam either by direct oil firing or from the heat of the exhaust gases, or both these sources of heat supply simultaneously. The heating surface is such that the designed output is 1350 lb. of steam per hour with direct oil firing and 850 lb. of steam per hour when utilising the heat from the exhaust gases alone. A new feature of the design is the patented centre air heater, a drawing of which is reproduced in Fig. 82. It shows the 13in. diameter welded heater, which has a hemispherical end, into which the inlet air is delivered by a blower. By means of the splayed and turned-up end of the inlet pipe the entering air is deflected over the inner surface of

the heating chamber, and the cooling effect prevents any burning out. The heated air passes up through the delivery outlet, which is attached to the upper cover of the heating chamber. It is claimed that by supplying hot atomising air to the oil burner the efficiency of the burner is increased and it is possible to burn heavier oil. By means of a mirror arrangement and special lighting the arrangement of the thimble tubes in the centre unit for oil fuel firing can be clearly shown.

THE MIRRLEES WATSON COMPANY, LTD.

The exhibits which were intended to be shown by the Mirrlees Watson Company, Ltd., of 45, Scotland Street, Glasgow, on the stand of its associated firm, Mirrlees, Bickerton and Day, Ltd., of Hazel Grove, Stockport, included examples of modern pumps for industrial and marine services, both steam turbine and motor driven, and a vacuum augmentor of the steam ejector type. The exhibit, which we illustrate in Fig. 76 on page 328, is a 3in. class "J A" horizontal-spindle, split casing pump designed for circulating water and general service duties on board ship, which is direct coupled to one of the firm's "F A 3" radial-flow steam turbines. The whole unit is mounted on a common bed-plate of the box type. The pump is so designed that the cover is free of external connections, and when removed gives free access to the rotor. The bottom casing of the pump, it will be noted, carries the supporting feet, and both the inlet and outlet connections. The joint between the two covers is metal to metal, and is carefully finished so that when the cover is replaced the correct position of the parts is maintained. The impeller is of the double-inlet pattern and is cast in gun-metal. Frictional losses are reduced to a minimum by machining all external surfaces and hand finishing inside surfaces as far as possible. All impellers are dynamically balanced after the machining and finishing operations have been completed. Renewable sealing rings of gun-metal are fitted inside the casings at the eyes of the impeller. The steel shaft is machined and ground, and within the pump and through the stuffing-boxes it is protected by gun-metal sleeves which are locked against the impeller. The long stuffing-boxes and glands are furnished with lantern rings and have water seals, while the main bearings are either of the ball or roller type. Standard fittings include an air cock, a priming connection, and drain plugs, also a lifting eye. In all, except the smaller sizes of pump, an inspection door on the casing cover is included.

The steam turbine is of the radial flow type, which has been developed with a view to putting on the market a well-designed and efficient turbine, which can be built at a comparatively low cost. It is built in the vertical as well as the horizontal form we show, and is specially suited for coupling direct to pumps, fans, blowers, exhausters, generators, and air compressors, especially in those cases where the exhaust steam can be utilised. The turbine is provided with a centrifugal type constant-speed governor, which is mounted on the turbine shaft and connected through levers and rods to the balanced throttle valve. In order to prevent overspeeding, there is a special device centrifugally operated from the turbine shaft, which is arranged to trip a stainless steel butterfly valve, should too high a speed be reached.

We show in Fig. 83 a self-priming marine type vertical centrifugal pump, which is representative of a wide range of pumps supplied for bilge, ballast, general service, fresh water piston cooling, jacket cooling oil transfer, and other duties on steamers and motor vessels. A special point in the design is the arrangement whereby the exhauster is only in operation when required, and is completely automatic in its action, being controlled by the main pump by means of a pressure-operated valve. As will be seen from our engraving, the pump is of vertical-spindle construction, the motor being mounted on the top of the pump frame and coupled to the pump shaft by a rigid coupling. A casing, split on the vertical centre line, is employed allowing easy removal of the cover half for inspection or overhaul, which can be effected without breaking pipe joints, as suction and discharge branches are both on the back portion of the pump casing, which is cast into the pump frame. The pump rotor can also be lifted out without disturbing the motor. The impeller is hydraulically balanced, and a ball bearing at the top of the motor carries the combined weights of the motor and pump rotors. Above the impeller the pump shaft runs in a long grease-lubricated bearing.

The air exhauster and its sealing water tank are mounted on either side of the main pump frame. The exhauster is of the single-acting water ring type, and is built as a self-contained unit with its driving motor. It consists of a rotor with radial vanes running in an excentric casing, which is partly filled with water. The action of rotation forms the water into a ring, which, in following the shape of the casing, alternately recedes from and is forced back into the spaces between the rotor vanes. This action draws and expels air through suitably placed suction and discharge

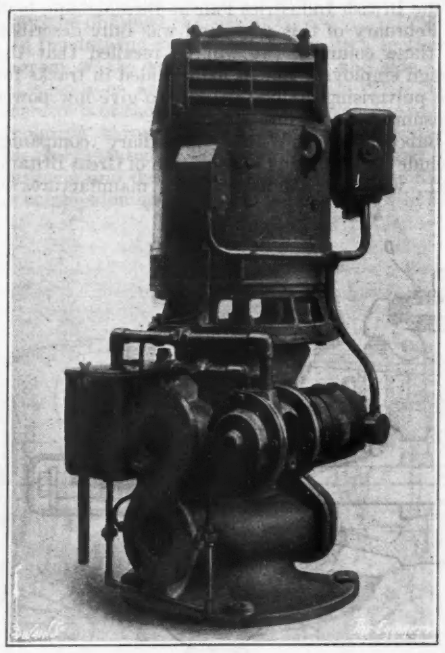


FIG. 83—MARINE PUMP—MIRRLEES

ports in the end of the casing. The exhauster casing can be very easily removed for inspection purposes without disturbing any pipes.

The suction of the exhauster is connected through a non-return valve to the highest point on the main pump suction branch, and the exhauster discharge is led to a small tank containing sealing water, which circulates between tank and exhauster all the time it is in operation.

On starting up the main pump, the exhauster also starts and exhausts any air which may be present in the suction line. Immediately the main pump gets water and pressure builds up in the volute, a pressure-operated switch comes into action and stops the exhauster motor. If the main pump loses water, this switch automatically starts up the exhauster again, and it remains running until the main pump has been reprimed. The exhauster is thus only running when it is actually required, and wear and replacements are reduced to a minimum.

The unit is claimed to be exceptionally silent in operation and it is stated by the makers that once started up it may be more or less left to look after itself. It is made in various sizes with branches from 2in. up to 8in., and capacities up to 340 tons per hour against all normal head requirements.

The third exhibit, which we illustrate in Fig. 74, on page 328, is a vacuum augmentor, which has been specially designed for use with installations embodying air pumps of the Edwards type. With such an installation, improvements of up to 3in. in vacua are, it is stated, being obtained with existing condensing plants. The augmentor consists of a single-stage steam ejector, and the heat of the operating steam can either be recovered in the body of the condensate, or by means of a special condensing chamber attached to the ejector similar to the one we illustrate. The system adopted in either case is very simple, and we are given to understand that the firm has supplied many sets of vacuum augmentors with coolers for use on British merchant ships.

RANSOMES, SIMS AND JEFFERIES, LTD.

Three standard electric battery trucks were to be exhibited by Ransomes, Sims and Jefferies, Ltd., of Orwell Works, Ipswich. One was a fixed platform truck of 2 tons capacity with two-wheel tiller steering and a loading platform 6ft. 9in. long by 3ft. 6in. wide and 1ft. 6in. high. It has foot-operated control and safety interlocking gear to prevent simultaneous application of braking and power. Solid rubber tyres are fitted to all the

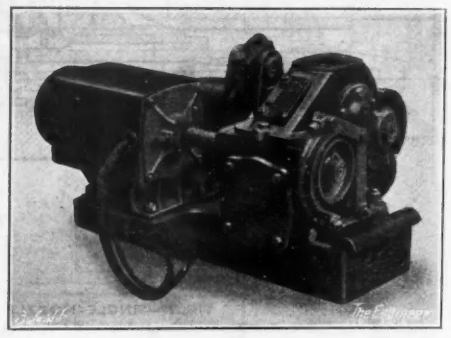


FIG. 85—ELEVATING GEAR—RANSOMES, SIMS

wheels. An "Exide Ironclad" battery composed of twenty 129-ampere-hour cells provides the power. Another truck has an elevating platform (Fig. 84) of 2 tons capacity and four-wheel tiller steering. The loading platform is 5ft. long and 2ft. 2in. wide. When the platform is lowered its height above the ground is 11in. and 15½in. when it is raised. The platform is composed of flanged mild steel plate and is operated by elevating gear (Fig. 85), with a

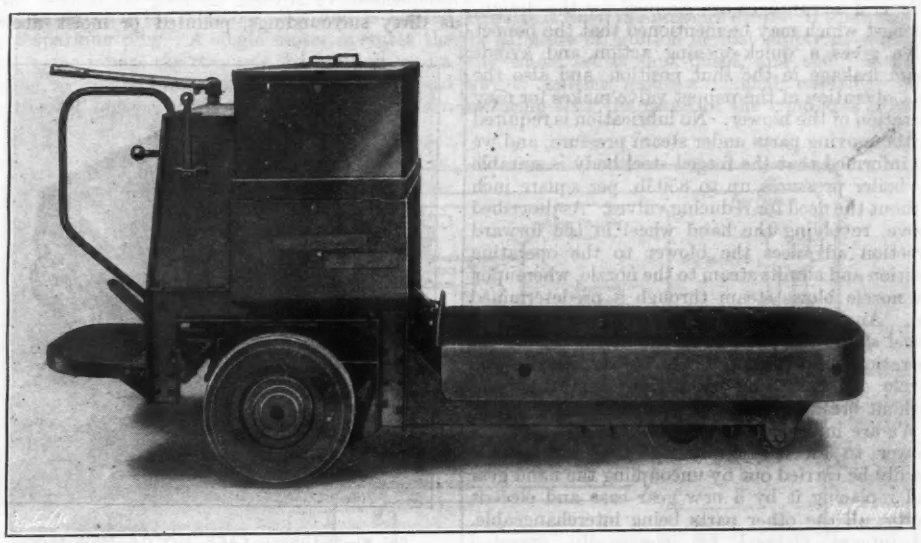


FIG. 84—ELEVATING PLATFORM TRUCK—RANSOMES, SIMS

separate motor. An automatic cut-out device operates when the platform reaches its top or bottom position. Control is effected by a foot pedal and safety interlocking gear is provided to prevent simultaneous application of power and braking. Solid rubber tyres are fitted to all the wheels. The battery is composed of twenty 129-ampere-hour "Exide Ironclad" cells.

The driving axle and gear (Fig. 86) are totally enclosed in cast steel housings, on which the motor is carried. The drive is by double-reduction spur

gearing and helical gearing manufactured from specially selected materials and mounted throughout on ball bearings. A four-pinion differential is incorporated and the shafts drive the wheels through universal ball joints. The whole of the gear runs in oil. Accurately machined to take standard tyres 20in. by 3½in., the driving wheels are mounted on ball bearings. Large wheel bearings allow the driving shafts and universal

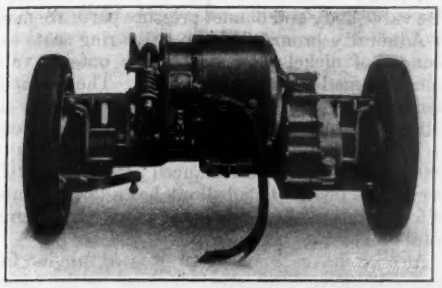


FIG. 86—DRIVING AXLE—RANSOMES, SIMS

joints to be readily withdrawn with the truck standing on its wheels.

The rear axle for four-wheel steering is shown in Fig. 87, and here again the wheels are mounted on ball bearings. Housed in an accessible position on the front of the truck the drum controller gives four speeds in either direction. An efficient external contracting brake normally "on" and with shoes lined with Ferodo acts on the motor shaft. It is interlocked with the controller and is actuated by the controller operating pedal. As we have indicated, it is impossible to operate the controller until the brake is released.

Where the service to be performed by an electric truck necessitates running for any distance along a public highway the Ministry of Transport regulations require two independent brakes, and in such cases an additional hand brake can be provided. An auxiliary pedal allows the truck to coast when running downhill, thus economising current consumption.

Tiller Ackerman steering is employed, and care has been taken to ensure easy operation. Ball and

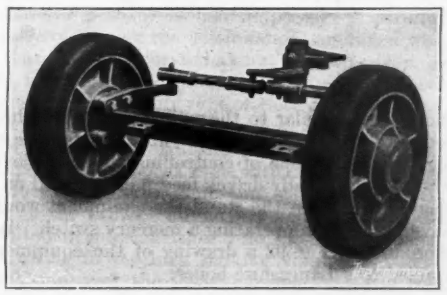


FIG. 87—TRAINING AXLE—RANSOMES, SIMS

socket joints are used throughout. The elevating platform is actuated by a reciprocating crank mechanism, which makes it impossible for the platform to overrun in either direction. Damage to the electrical equipment is thereby eliminated. The elevating motor, which is of Ransomes, Sims and Jefferies' own make, is capable of developing a high torque for short periods. It is series wound, totally enclosed, and built in accordance with the British Standard specification. The control of the elevating motor is simple. No reversing switch is required, as the reversal of direction of the load platform is performed by the reversing crank mechanism. A simple push-pull switch is linked with the elevating mechanism, and as soon as the platform begins to rise or fall the switch is automatically held in the closed position until the limit of travel is reached. At this point the cam on the operating gear causes the switch to open, thus interrupting the supply to the motor. With the exception of the motor, the bearings of which have grease cups, all parts where lubrication is required are provided with nipples for use with the "Tecazerk" grease gun included in the kit of tools.

Another truck by the firm is a battery-operated tiering unit of 2 tons capacity with four-wheel steering. The load platform is 4ft. 6in. long by 3ft. wide. The minimum height of the platform above the ground is 11in. and the maximum height 5ft. Composed of flanged mild steel plate, the platform is provided with elevating gear actuated by a separate motor with an automatic cut-out device which operates when the platform reaches its top or bottom position. Foot-operated control gear and safety interlocking gear to prevent simultaneous application of power and braking are provided. Solid rubber tyres are fitted to all the wheels. Like the other trucks described, steering is done with a tiller. An "Exide Ironclad" battery composed of twenty 161-ampere-hour cells provides the power. The firm was also to have exhibited a standard truck driving unit and a standard elevating gear.

NEGRETTI AND ZAMBRA

One of the most interesting of the exhibits of Negretti and Zambra, of 38, Holborn Viaduct, London, E.C.1, was to have been a 10in. electrical temperature indicator. This device is illustrated in the accompanying half-tone engraving, Fig. 88. The mechanism is enclosed in a die-cast case

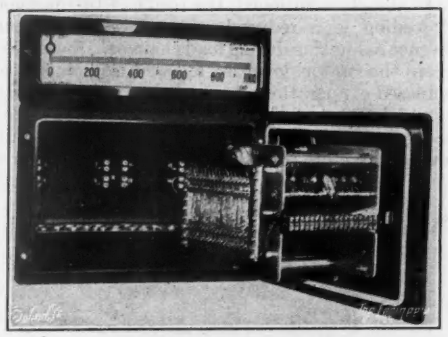


FIG. 88.—TEMPERATURE INDICATOR—NEGRETTI

finished in black enamel, and is mounted on the back of the front panel which hinges outwards as shown in the engraving. Such an arrangement obviously facilitates the making of connections and balancing of circuit resistances. Temperatures can be measured at sixteen points. For selection hermetically sealed dust and fumeproof mercury-in-glass switches are used. There is a dial on the front of the case, and as contact is made with each point a small panel in the dial is illuminated, making visible a number or a title. The device has a sensitivity of 20 ohms per millivolt. Automatic cold junction control is fitted as standard when used with thermo-couples. A second engraving, Fig. 89, illustrates the firm's

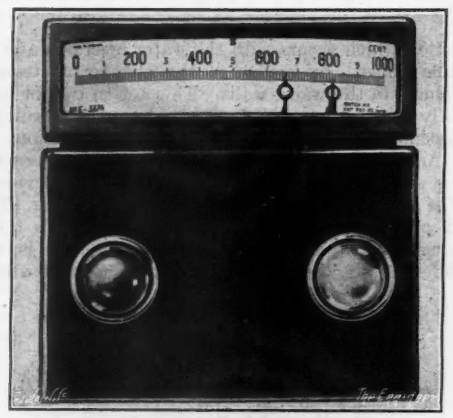


FIG. 89.—THERMOCOUPLE CONTROLLER—NEGRETTI

thermo-couple type controller which has a sensitivity of 20 ohms per millivolt, automatic cold junction control, and valve position signal lights. It can be arranged for "on-off" control, "floating" or "throttling" control, or for two-speed valve operation. Mercury-in-glass switches are used to operate control valves or contactors without an intermediate relay. A broken thermo-couple device can be added. It cuts off the heat supply and illuminates a warning light. This controller is available for temperatures up to 1200 deg. Cent.

KRYN AND LAHY (1928), LTD.

Steel castings of various kinds were to have been shown by Kryn and Lahy (1928), Ltd., of Letchworth. They would have included examples of ships' davits, steam chests, stop valves, railway castings, including wheel centres, excavator and crane castings, traction motor frames, &c. Some years ago, it will be recalled, this firm put on the market a material known as "Stronger Steel," which combined high strength with ductility and was guaranteed to have a tensile strength of 35–40 tons per square inch, an elongation of at least 20 per cent. on the standard B.S.S. test piece, and to bend cold without fracture through 120 deg. in the form of a standard B.S.S. test piece. These were remarkable figures for cast steel and the material found many uses. The firm has now produced another material known as "High Shock" steel, which combines the properties of "Stronger Steel" with the ability to resist shock. It has a yield point 60 per cent. or more of the ultimate tensile strength and an Izod resistance of not less than 20 foot-pounds—about twice the normal figure for carbon steel castings with the same tensile strength. These properties, it may be emphasised, are obtained without the necessity for drastic heat treatment. A typical example of the application of the new material is provided by the bed-plate for an excavator, illustrated in Fig. 90. Such castings are liable to be

FIG. 90.—STEEL CASTING—KRYN

subjected to sudden and repeated shocks in service. Automatic couplers for rolling stock and ships' davits, both exhibited, provide other examples. When the firm introduced "Stronger Steel" the Board of Trade and Lloyd's authorised the use of davits for loads 25 per cent. greater than had previously been permitted. With the recent advance in yield point and shock-resisting properties, so the firm informs us, certain davits for special purposes have recently been approved by the authorities for further increases up to 15 per cent. of loading for the same frame size. The accompanying Table gives the results of tests taken in the

TABLE

	Test piece No. 1.	Test piece No. 2.
Date stamped	10/1/1939	10/1/1939
Ultimate breaking point, tons	10·0	9·95
Tensile strength, tons per square inch	40·0	39·8
Elongation, per cent. on 2in.	27·0	25·0
Yield point, tons per square inch	28·0	27·6
Yield ratio, per cent.	70·0	70·0
Bend test angle, deg.	120	120
Remarks	Without fracture	Without fracture
Brinell Test		
Diameter of impression		4·50
Brinell number		179
Approximate tons per square inch		39·0
Izod Test		
Diameter of bar, 0·45in. with three notches.		Ft.-lb.
First notch		43
Second notch		39
Third notch		40
Average of three notches		40·66

presence of B.O.T. and Lloyd's surveyors at the firm's works. The diameter of the test pieces was 0·564in., giving exactly 0·25 square inch area. The firm also intended to show examples of Coborn air-cooled petrol engines providing outputs from 2 to 6 B.H.P., and to have staged a display of aircraft components, the manufacture of which was recently taken up by the firm.

PERRY AND CO., LTD.

A wide range of chains and chain drives was prepared for exhibition on the stand of Perry and Co., Ltd., of Tyseley, Birmingham. The exhibits

would have included samples of light and heavy single, duplex, and triplex roller chains, long pitch chains, bush chains, balance chains in a variety of pitches and widths, and special chains designed for many applications, including use on conveyors. Other products of the firm which would have been shown are chain couplings and many types of chain wheels.

Recently the firm has developed a special range of chains for aircraft control applications, including stainless steel chain, which is of particular interest, in view of its low magnetic permeability. These chains, supplied under the firm's own A.I.D. approved inspection and release arrangements, should be of interest to the shipbuilding industry, since the stainless steel chain can be used in the vicinity of a magnetic compass, whilst the standard steel chain is claimed to be resistant to sea water spray and is therefore particularly applicable to steering and auxiliary mechanisms.

COPES REGULATORS, LTD.

The chief exhibit on the stand of Copes Regulators, Ltd., 5–11, Theobald's Road, London, W.C.1, was to have been an arrangement for automatic feed water regulation for boilers, known as the "Flowmatic" feed water regulator. The arrangement comprises a thermostat designed to move the feed regulating valve in accordance with the changes in water level, and an additional controller operated by changes in the rate of steam flow, and participating in the movement of the regulating valve. In the intended exhibit the regulating valve was the firm's "G.A." type, which incorporates compensation for variations in boiler and feed pressure and has a manually adjustable valve area. It is claimed that the "Flowmatic" equipment is very simple and enables boilers to be fed correctly under rapid load-change conditions, thus reducing water-level swings.

In the accompanying diagram, Fig. 91, the arrangement of the components is shown. The thermostat is mounted as shown at a mean boiler water level. It is provided with an expansion tube maintained in tension and is mechanically connected to the feed regulating valve. The operation of the firm's standard "G.A." regulating valve is, of course, well known, as it is fitted on many 600 lb. pressure boilers in this country. The "Flowmatic" controller consists of a diaphragm connected across the superheater, so that the variations in drop in pressure which occur as the change in the rate of steam flow varies, actuate a lever. This lever, as shown in the diagram, is connected by a chain motion to rotate the spindle of the regulating valve; after passing round the valve spindle sprocket the chain is connected to the thermostat lever.

The regulating valve is designed to control a large flow of water without chatter or the use of auxiliary power. It is moved rotatably by the action of the controller and thermostat, described above, and reciprocally by the change in pump or boiler pressure, and the consequential friction loss changes. The flow of water out of the valve proper is in the direction of the valve axis, and the valve is streamlined in this direction, hence it is claimed that no chatter occurs and that the valve moves easily when throttling high-pressure flows. The water flows through taper ports in a stationary valve sleeve which is designed to absorb much of the out-of-balance flow force, allowing the plunger inside to move freely. The valve has V-shaped ports, designed for individual boiler capacities, and the sleeve has rectangular ports.

In the "Flowmatic" arrangement, whenever the water level varies the thermostat responds and attempts to move the feed regulating valve; but the controller also acts if there is a change in the rate of steam flow. Consequently, when a sudden boiler load decrease occurs, and the water level falls by reason of the lessened volume of steam in the water walls, the thermostat is not permitted suddenly to open the valve and feed an increased amount of water. The controller will override the action of the thermostat and keep the rate of flow correctly balanced in accordance with the steam flow. In the reverse case, on a sudden increase in load, when the water level is suddenly driven upwards, the feed is not immediately shut off by the action of the thermostat.

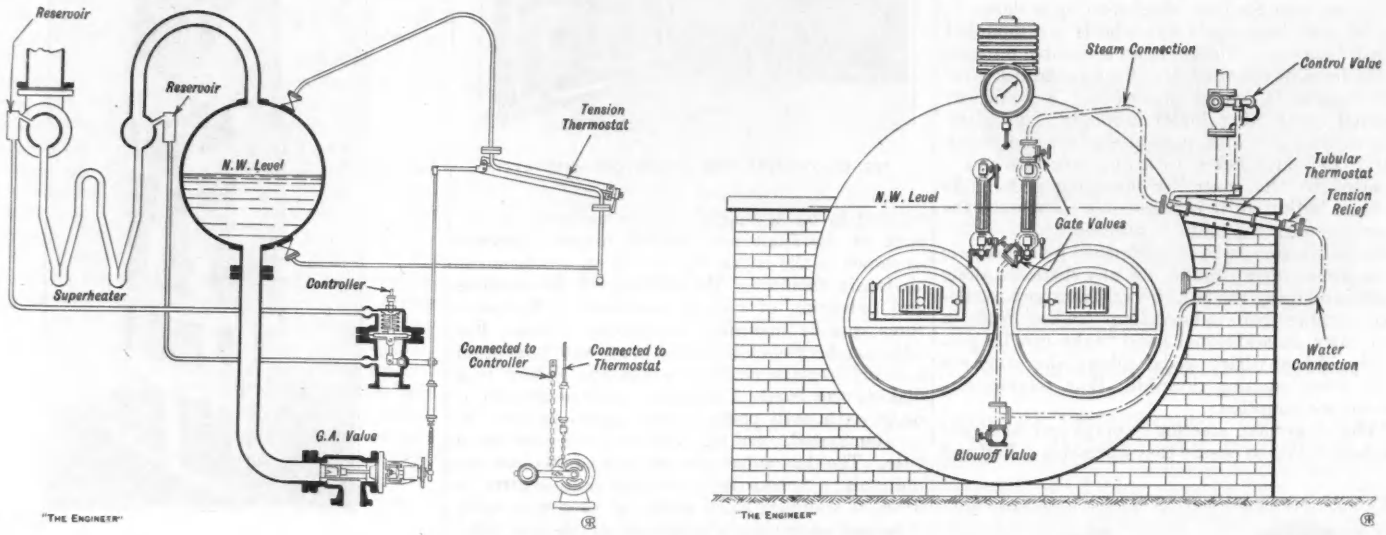
As already mentioned, the result of this method of feeding is a reduced water level swing and absence of hunting during load changes. Naturally, when the water level is lowered by reason of increased evaporation, however, both the thermostat and the controller act in unison to open the feed valve, and *vice versa*. The effect of the equipment is therefore to make provision for the reverse action which occurs with the water level of water-tube boilers, by reason of the change of steam volume in the water walls. This action cannot be fully allowed for in a feed water regulator which depends solely on the water level for its operation.

Another exhibit was to have been a governor for steam-driven pumps for boiler feed service. The arrangement is shown in the drawing, Fig. 93. It operates on what the firm describes as the constant excess pressure principle, for it is a differentially operated device which compensates for changes in steam pressure as well as water pressure. It is claimed that for feed water regulation the ideal method is to maintain a fixed pressure across the feed water regulator control valve, or hand check valve, irrespective of changes in steam pressure. This result is said to be attained by the use of a governor working on the differential principle.

The governor is an automatically controlled balanced valve, intended to be fixed in the steam supply main to the feed pump. It is provided with a valve plunger moved in a straight line by the means of a sylphon bellows actuated by variations in pressure. Steam pressure acts on the inside of the sylphon bellows, since steam condensate fills this area, and the main water header pressure is carried to the space outside the sylphon. The excess feed pressure over the boiler pressure is determined by the position of a weight on a lever connected to the valve. In this way a fixed excess pressure is maintained by governing the pump speed.

A range of sizes from ¾in. to 2in. is available. The valve body and bonnet pressure parts are made of Admiralty bronze and the valve ring seats and plunger of nickel-alloy steel. The outside valve spindle is made from stainless steel. The actuating element is a sylphon bellows made of three-ply rolled brass, brazed to bronze flanges at each end. It is claimed to withstand a temperature of 400 deg. Fah. and an unbalanced pressure of 300 lb. per square inch. This bellows has a large number of folds, so that the stress in the metal for the small total movement is low.

Also to have been shown was a tubular feed water regulator, designed for use with Lancashire, waste heat, and cylindrical boilers. The arrangement is a more compact and less refined regulator than the "Flowmatic" arrangement described above; it consists of a tubular expansion thermostat, similar to the unit already described, connected to the boiler feed valve. This type of regulator is capable of controlling the water level when an electrically driven feed pump is used on a single boiler. On the stand the equipment would have been shown operating a mercury switch. We reproduce in Fig. 92 a drawing of the equipment applied to a Lancashire boiler.



FIGS. 91 AND 92—FEED-WATER REGULATOR—COPES

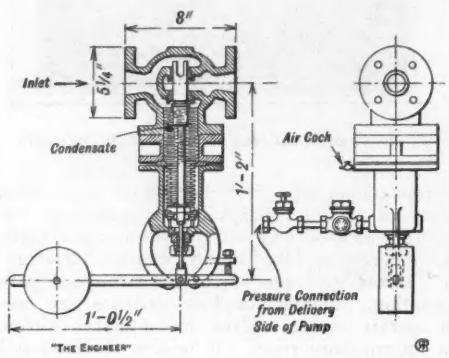


FIG. 93—FEED PUMP GOVERNOR—COPES

DETEL PRODUCTS, LTD.

On the stand taken by Detel Products, Ltd., of Greenford, Middlesex, would have been exhibited a variety of anti-corrosive materials made from Detel chlorinated rubber. In addition to a product known as "D.M.U.," referred to below, the firm makes paints which are claimed to be highly resistant to attack by acids or alkalis, as well as a new product in the form of chemically inert rubber. The last-named material is made in sheet form of varying thicknesses and is claimed to resist acid and alkali attack, to be unchanged by oxidising agents, to be non-inflammable, and to be flexible.

The product referred to above as "D.M.U." is of particular interest to engineers and shipbuilders. It is a zinc coating, which becomes particularly hard when it is exposed to sea water. It can be applied to iron and steel by means of a paint brush or by spraying, and, unlike metal spraying, with which, we are informed, it can alone be compared, it requires no sand blasting. The compound is claimed to dry quickly, giving a coating containing more than 90 per cent. of metallic zinc in electrical contact with the underlying metal. Furthermore, corrosion is said to be completely prevented under the coating, so that the "creep" of rust which occurs frequently under apparently sound paint films is impossible. By reason of the "anodic" character of the protection it gives, the material is able to protect a slightly larger area than it itself covers; hence scratches in the protective coating will not rust for a long time, even though they penetrate into the underlying metal. But,

since the protection conferred by the material is anodic, it is essential that it be applied directly to the surface of the metal without any intervening electrical non-conductor. The product is grey in colour and after exposure can be polished with fine sandpaper to a smooth zinc-like surface. If another colour or finish is required an ordinary good quality paint can be applied as a top coating.

PETBOW, LTD.

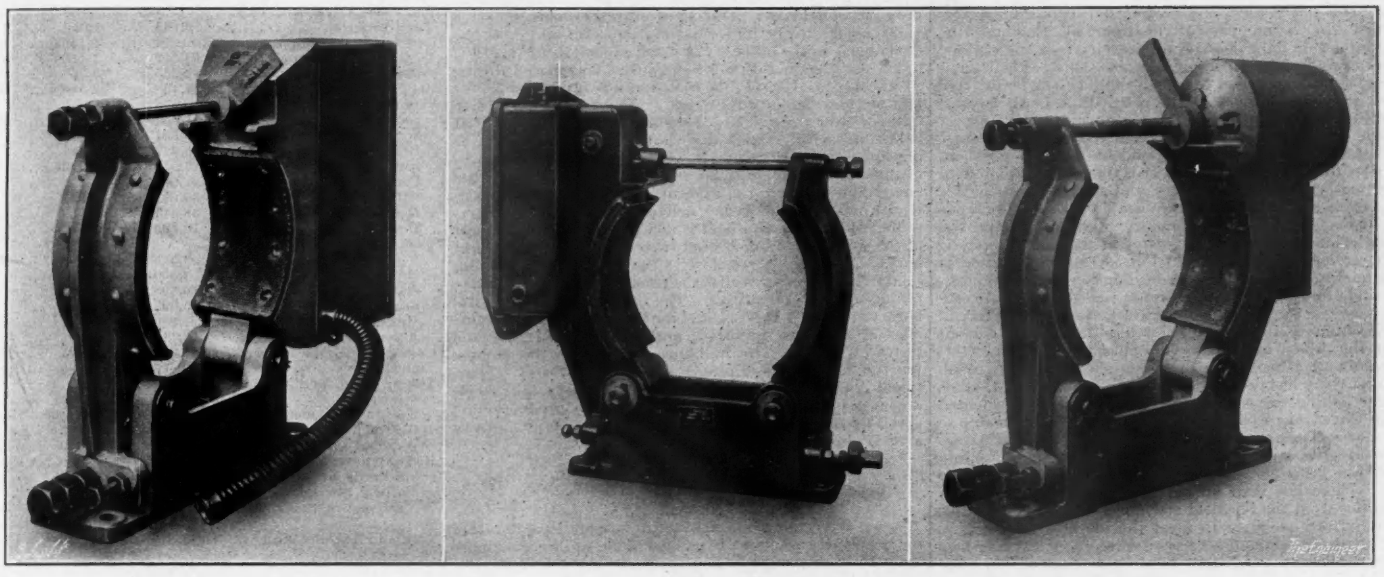
Petbow, Ltd., of Station Estate, Balmoral Road, Watford, Herts, intended to exhibit a new transformer welding set believed to be the first oil-cooled unit with stepless regulation to be produced. All the components are housed in a welded boiler plate tank. Current control is effected by a selector switch giving a high and low range. A hand wheel gives infinite variation over the two ranges, which are 15/80 ampere and 70/265 amperes, respectively. The maximum output for continuous hand welding, as rated under B.S.S. 638, is 235 amperes. A striking voltage of 80 over the whole range, combined with a characteristic curve having a steep drop, is said to give an exceptionally steady and smooth arc, and to enable any type of electrode to be used, even by a comparatively inexperienced operator.

Of two other transformer sets, one is an inexpensive air-cooled unit with an output range of 40/160 amperes, and the other a modification of the firm's "Junior" welder. It provides infinite current regulation from 15 to 100 amperes, and owing to the high striking voltage and close regulation over the lower current values it is a very suitable set for sheet metal work. The welding of 24 S.W.G. plate is perfectly practicable. Although it is not continuously rated, at the higher outputs, it is designed primarily for sheet metal work on which the higher currents are only occasionally needed, or alternatively for maintenance and similar occasional work where there are insufficient welding jobs to justify the use of a larger machine. A special feature of the set is a safety thermostat which immediately indicates an unsafe winding temperature.

Another product is a portable welding plant driven by a petrol engine mounted on a two-wheeled trailer for towing. The 250-ampere generator is flange mounted on the four-cylinder, water-cooled engine equipped with an electric starter. Welding current control is obtained by a portable regulator which, when welding is being carried out, is placed alongside the operator. When it is being transported it is housed on a rack inside the set. The "dropped" axle gives a low centre of gravity, and consequently stability when towing. A high steel canopy provides weather protection, and a large locker ample stowage for cables, electrodes, and tools.

DEWHURST AND PARTNERS, LTD.

The intended exhibits of Dewhurst and Partners, Ltd., of Inverness Works, Hounslow, consisted of electro-magnetic brakes and drum type air break controllers. The brake shown in Fig. 94 is for single-phase supplies. Pressure on the shoes is obtained from two compression springs in the base of the brake and can easily be adjusted. Adjustment for wear on the brake lining is also easily made. These shoe linings are composed of woven fibre and in normal use are said to have long life. The laminated core is of high permeability, low-loss iron, and is secured by heavy rivets. All-steel pins and set screws are made rustproof by the Parkerising process. On all brakes from 6in. upwards a simple hand release is fitted. Provision can be made for an attachment to enable the brake to be released by a foot pedal, if required. As shown in the illustration, coils and terminals are enclosed and a ¾in. flexible tube is supplied for coupling to the conduit. All parts are jig drilled.



FIGS. 94 TO 96—SINGLE-PHASE, THREE-PHASE AND D.C. ELECTROMAGNETIC BRAKES—DEWHURST

The shoes are bored after assembly in a special jig, which ensures an accurate height of centre. As regards fixing centres, height of centre, and torque, the brakes are interchangeable with the firm's corresponding three-phase and D.C. brakes (Figs. 95 and 96).

The drum air brake controller, shown in Fig. 97, has hinged contact arms fitted with heavy copper renewable contacts and calliper springs. Renewable hard-drawn contacts are fixed to the cast iron drum. D.C. controllers are fitted with powerful series-wound magnetic blow-outs. Moulded arc shields are designed to permit of easy replacement, and the shields and blow-out can be moved away from the contacts as one unit for inspection and maintenance. At the bottom of the controller is a cable entry and ample room is allowed on the controller itself for easily accessible terminals and adequate earth clearances. Cable glands and sealing boxes can be mounted at the back of the controller. The standard lever handle has a star wheel and spring register, to indicate each operating position and the neutral position. Other types of handles or wheels can be supplied and all types can be provided with or without spring return to the neutral position.

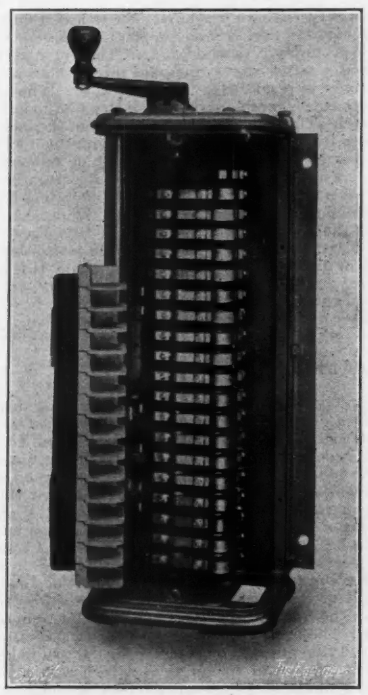


FIG. 97—BRAKE CONTROLLER—DEWHURST

The resistances mounted in a separate ventilated framework are wound with resistance alloy wire having a negligible temperature coefficient on ground porcelain formers. Although the standard practice is to rate the resistances for five minutes' operation, they can be rated for two or ten minutes' service. Controllers and resistances conform with the British Standard Specification No. 587–1938.

KEITH PIERCY, LTD.

Keith Piercy, Ltd., of Shell-Mex House, Strand, London, W.C.2, would have shown a range of phosphates for water treatment and demonstrated various methods of scale prevention. Boiler feed water conditioning, which is one of the company's main activities, would have been dealt with fully, and apparatus for testing boiler water, including a simple test kit, which may be used by a boiler operator for making rough check analyses to ensure that treatment is being properly carried out, would have been shown.

A recent development consists of the use of sodium metaphosphate, known by the trade name of "Calgon," for treating the water. "Threshold treatment"—so called from the fact that it raises the threshold concentration at which calcium carbonate will precipitate and form scale—consists essentially of the use of small concentrations of "Calgon" for the prevention of scale in cooling systems, &c. The treatment is not to be confused with feed water conditioning or water softening. Chief interest in the stand would have centred on a working model showing the effect of "Calgon" in a water cooling system. The model represents two condensers; in one of them scale is shown forming on the hot surface as a result of calcium carbonate being precipitated; while in the other the system is maintained in a scale-free condition by the remarkably small dose of two parts "Calgon" per million parts of water. Ease of control and simple dosing gear are claimed for the treatment, and we are informed that the process has been applied with success to condensers, feed heaters, distillation plant, gas coolers, oil engine jackets, &c. This treatment is also being used to prevent incrustation of pipe lines and filters in municipal water supplies and softened water mains generally, and it can be employed in the wayside treatment of locomotive feed water.

(To be continued)

GOLD MINES.—Statistics from a Canadian source show that of the 55 gold mines in the world that produce more than 100,000 ounces annually, 10 are in Canada. These are Hollinger, Lake Shore, Noranda, McIntyre, Wright-Hargreaves, Dome, Lamaque, Hudson Bay, Teck-Hughes and Bralorne. It is noteworthy that 46 of the 55 largest gold mines are under British control, divided as follows:—South Africa, 32; Canada, 10; Gold Coast, 2; Australia, 1; Rhodesia, 1. The largest producer is Crown Mines in the Transvaal.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer.

The Pig Iron Market

There is a tendency for business gradually to expand under the stimulus of war requirements. This applies to every department of the market but is less noticeable in the high phosphoric foundry iron section than in others. The needs of the light castings industry, which is the largest user of ordinary foundry grades, have increased to some extent and the foundries appear to be better employed than for some time. The demand, however, does not involve any particular pressure upon producers. In a number of districts in England the comparatively light demand for foundry iron has enabled users to undertake repairs and renovations to their plant and to equip themselves to meet a possibly heavier demand later on. The position on the North East Coast has not altered. There have been some complaints of transport delays owing to the wartime pressure upon the railways, but these are becoming less evident as time goes on. Subject to the provision of licences the makers are able to give reasonably early delivery and the position in this respect seems to be fairly comfortable. In the Midlands the demand for ordinary foundry grades has improved slightly but the activity is greater in the low phosphoric iron section of the market. Considerable quantities of this quality are passing into consumption in the engineering and other branches of the trade engaged upon Government contracts. The price of the latter is uncontrolled and varies from £5 10s. to £6, but reports have been current that this iron will be brought under the Iron and Steel Control both as regards price and supplies. In the Scottish market there has been a steady business passing and some of the light castings industries appear to have benefited from Government orders. The position is comfortable so far as supplies are concerned and most of the makers are able to give early delivery. Business in hematite iron has been brisk and considerable tonnages are going into use. There has been an active demand for East Coast qualities from the Sheffield steelmakers. Supplies of this material are adequate to meet the market requirements and most of the manufacturers are receiving a steady flow of specifications against existing contracts. A fair amount of business has been entered into lately although for the most part consumers covered well forward at the end of June. The production of basic iron continues at a very high rate and appears likely to reach record proportions this month.

The Midlands and South Wales

With the Midlands iron and steel industry working at full pressure upon Government requirements there is little opportunity for placing orders for ordinary commercial needs. Generally speaking the Control is working smoothly and with less disturbance to trade than had been feared. Consumers requiring steel for purposes which do not come within the seven priority classes realise that they must wait and are accepting the situation as an unavoidable consequence of the war. The re-rolling industry in the Midlands continues to produce a heavy tonnage of small bars, sections, and strip and supplies of semis are coming forward better than had been expected. The works are rationed and of course preference is given in distributing billets and sheet bars to those firms which are engaged upon Government work. In spite of the difficulties which always affect an industry in war time the output of the rerolling works is being well maintained. The steelworks are being subjected to intense pressure from consumers in all departments. Heavy as the demand was previous to the war it has been greatly increased during the past three weeks and consumers of bars, structural steel, and plates are in many cases pressing to secure accelerated deliveries. The Control, apparently, is endeavouring to arrange deliveries against contracts in accordance with the importance of the national work for which the material is to be used. All the constructional engineering firms are busy and their requirements take up a good proportion of the output. The needs of the Government Departments, also, amount to a large tonnage and in the majority of cases these receive priority. Locomotive builders have considerable contracts in hand and the tank makers also are busy. The Galvanised Tank Manufacturers' Association has allowed it to be known that it does not for the time being intend to increase its prices, but in common with many other branches of the steel trades its members fear that the price position in the future may become difficult. So far, however, the official quotations are the same as those ruling before the war and the price of spelter is controlled at about the same level as the London Metal Exchange quotation on September 1st, the last day on which an open market was held. The requirements of the collieries remain on a good scale and as this industry comes within the priority scheme large quantities of rails, arches, and roofing bars are passing steadily into consumption. In South Wales the iron and steelmakers have brought practically all their plant into operation. The heavy steelworks already have contracts in hand sufficient to keep them employed for months to come. Orders, however, continue to be pressed upon them but only those which can claim priority can be accepted. The tinplate industry is active and is operating at about 65½ p.c. of capacity whilst 94 p.c. of the steel furnaces in South Wales are in operation.

Scotland and the North

So great a proportion of the output of the Scottish works is for national purposes that the industry may be said to be devoted to war requirements. The fact that there is no shortage of pig iron, scrap, labour, or fuel, enables the Scottish industry to maintain outputs at probably record levels. The shipyards are taking huge quantities of steel whilst the demand for constructional engineering work has if anything increased since the outbreak of war. The marine and general engineering trades are fully employed and in all cases production in all departments is being pressed to the utmost. The sheet industry has been fully occupied for months past and there is no decline in the activity at the works. Very large tonnages of galvanised sheets are being produced for A.R.P. and other national purposes and there is little surplus production in this department available for export. Consumers requiring sheets for ordinary commercial purposes have to be content with indefinite promises of delivery. The heavy output of black sheets is also passing freely into consumption. Sheet prices are unchanged on the basis of £13 15s. for black sheets 11–12G. d/d whilst the quotation for galvanised corrugated sheets, 24–G. basis, d/d is, £17 5s. for 4-ton lots up to £19 5s. for lots of from 2 tons to 10 cwts. Whilst business in bar iron is better than of late the works are still operating at below capacity. Gradually, however, the situation is improving and the requirements of engineering establishments are expanding. A certain number of orders are being diverted from the steelworks to the malleable ironworks owing to the earlier delivery obtainable. The rerolling industry in Scotland is in a good position and most of the works have substantial reserves of billets and sheet bars. There is a particularly strong request for bars for reinforcing purposes whilst the rivet and plate makers are taking up good quantities. The quotation for mild steel bars, untested, is £11 12s. and for tested material 3s. more. Mild steel hoops, untested, are quoted at £12 7s. and tested at £12 10s. In the Lancashire market the demand for the heavier descriptions of structural steel is particularly active whilst good quantities of plates and sheets are also passing into consumption. The production of special steels is expanding and business in bright drawn steel is also at a high level.

Copper and Tin

The copper market is still suspended but rather more business seems to have been done as larger supplies seem to have passed to firms engaged upon Government work. The merchants, however, are debarred from dealing by the operation of the Non-Ferrous Metal Control and a blow was struck to this branch of the trade by the announcement by the Control that " in no circumstances may any sum in respect of war risk insurance be added to the maximum prices laid down in the Non-Ferrous Metals Orders." This, of course, means that as merchants are unable to buy at less than the maximum prices they incur a loss on any transaction they may enter into. It is argued in the trade that merchants should be allowed to charge a definite percentage on the maximum prices. Since the declaration of war the merchant business in electrolytic copper has ceased to all intents and purposes. The heavy buying which America indulged in in the first few days of the war has not been maintained but it is anticipated that the figures for the producers' sales for September will amount to a very high total. It is estimated that during the first week of this month the sales amounted to nearly 123,000 tons. How much of this buying was speculative it is impossible to ascertain but the general view is that a fair proportion represented the actual consumptive demand. . . . The tin market has developed a rather easier tone and prices this week have occasionally slipped back to below £230. The general view is that this represents the liquidation of metal which had been held for higher prices as a result of the increase in the quota by the International Tin Committee to 100 p.c. There has been some talk in Holland of removing the restriction upon production but little attention has been paid to this in the market. Considerable feeling has been expressed amongst metal merchants at the decision of the Control that dealers must not buy in the East at the official maximum prices which have been established there and sell at higher prices in neutral countries. It is pointed out that foreign dealers do not suffer from any such restriction and that British merchants are likely to lose a business in tin which has been built up over many years.

Lead and Spelter

The British market for lead remains suspended and all sorts of prices are reported from America and other neutral sources. In this country good quantities have passed into consumption and it is generally understood that the position so far as supplies are concerned is quite comfortable. It had been hoped that before this date arrangements would have been made with the Ministry of Supply for reopening the market, but apparently no decision has yet been reached. It is reported that some of the German ships which have sought refuge in neutral ports have Australian lead on board destined for Great Britain and this seems quite likely since before the war much of the Australian metal was shipped here in German vessels. The most satisfactory feature of the situation is that consumers are obtaining regular supplies. . . . The consumption of spelter is at a high rate and is not likely to diminish for many months to come. Whilst there is no open market it is impossible to give any real description of the position but at least consumers are getting all the metal they require. Merchants are awaiting some change in the present regulations which will enable them to resume business. An official statement was made in Australia that the British Government would buy the whole of the Australian export surplus of refined zinc at quotations about the same as those ruling before the outbreak of hostilities.

Iron and Steel Exports

The exports of iron and steel and manufactures thereof in August, according to the Board of Trade Returns, fell to 135,651 tons, valued at £2,781,298, compared with 177,226 tons valued at £3,490,438 in July. The following are details of the principal exports :—

	1938. Total. Tons.	1939. July. Tons.	1939. August. Tons.
Pig iron : Total	94,012	5,872	6,725
Forge and foundry	44,375	4,057	4,452
Acid	25,690	1,779	2,273
Basic	23,947	36	—
Ferro-alloys	6,787	245	990
Sheet bars, bright steel bars, and wire rods	22,162	1,056	1,029
Bars and rods, other kinds	102,074	6,135	5,885
Angles, shapes, and sections	67,319	7,110	4,194
Girders, beams, joists, &c.	33,525	3,202	2,388
Hoop and strip	37,408	2,566	3,447
Plates and sheets, ¼in. and over : Total	131,052	20,084	9,622
South Africa	7,551	1,270	415
British India	16,926	801	386
Australia	7,551	379	358
Canada	1,966	863	682
Other British countries	30,085	1,955	1,241
Denmark	38,611	7,633	1,467
Holland	10,633	4,791	3,560
Plates and sheets under ¼in. : Total	63,516	5,960	6,149
British India	4,550	255	326
Australia	16,398	240	234
Canada	5,097	609	821
Mexico	1,880	—	—
Argentine Republic	13,113	2,408	1,469
Galvanised sheets	147,332	11,897	12,051
Tinned plates	319,403	34,985	28,646
Tubes, pipes, and fittings : Cast :			
Up to 6in. diameter	48,985	5,844	3,559
Over 6in. diameter	42,946	4,675	4,116
Wrought	220,011	18,659	12,590
Railway material :			
Steel rails, new	105,999	10,360	6,742
Sleepers, fish-plates, and sole-plates	25,618	1,263	1,159
Total, all iron and steel	1,917,639	177,266	135,651

Iron and Steel Imports

The following figures, taken from the Board of Trade Returns for August, show that imports of iron and steel and manufactures thereof increased to 236,920 tons from 220,646 tons in the previous month, and the value to £2,123,563 from £1,910,683. Only the figures for the most important countries are given :—

	1938. Total. Tons.	1939. July. Tons.	1939. August. Tons.
Pig iron : Total	395,151	29,325	35,900
British India	155,653	22,902	20,542
Foreign countries	231,365	4,419	7,198
Ferro-alloys	47,606	7,782	6,450
Blooms, billets, and slabs : Total	314,989	43,689	54,059
British countries	59,462	15,087	12,172
Sweden	1,104	36	60
Germany	27,569	1,876	3,529
Belgium	55,417	10,482	12,555
France	101,188	15,541	16,621
Other foreign countries	70,249	667	9,112
Sheet bars	33,606	79,449	71,408
Wire rods	60,021	6,689	7,575
Other bars and rods	102,919	12,212	12,195
Angles, shapes, and sections	44,958	6,564	5,769
Girders, beams, joists, &c. : Total	60,134	4,435	5,718
Belgium	5,493	665	697
France	38,191	638	2,420
Other foreign countries	14,534	3,132	2,601
Plates and sheets (not coated)	68,009	11,986	10,747
Wrought tubes	22,880	2,502	3,770
Railway material	20,458	739	698
Bolts, nuts, and metal screws	7,109	1,030	884
Total from countries :			
British India	155,664	22,902	20,542
Canada	117,051	22,633	21,051
Germany	94,685	9,673	10,933
Sweden	89,804	8,629	13,014
Holland	32,583	431	287
Belgium	273,586	53,746	55,866
Luxemburg	58,570	18,169	23,210
France	257,304	49,037	44,239
Czechoslovakia	12,367	610	118
United States	20,671	4,703	11,359
Total imports, iron and steel	1,340,735	220,646	236,920

SYNTHETIC MICA.—In a paper before a scientific institution in the United States Dr. E. A. Hauser described a new type of transparent film, made from clay, which can be used as a substitute for mica. According to particulars given in *Shipbuilding and Shipping Record* the clay used is a specially pure type of Bentonite, made up of alumina, silica and water, and the individual particles are so small that most of them fall within the colloidal range. It has been found that the finer part of the colloidal fraction of the clay, when mixed with the appropriate amounts of water, forms a gel. If this gel is evaporated, the particles draw towards one another in such positions that they become permanently fixed by their attraction for each other, in strings or tiny fibres. These strings in turn mat together in a similar manner to the matting of wood fibres in forming paper, or wool in felt, so that the resulting structure is that of a tough, coherent, independent film. Known as " Alsifilm," the material may be made thick, so that it is stiff and brittle, and in this state is proposed as a substitute for mica, for it has the appearance of mica and similar electrical properties. Dr. Hauser, in presenting his findings, stated that the new film may be made completely inert to oils, grease, organic solvents and strong acids.

Rate of Oxidation of Steels

INTERFERENCE colours, or "temper colours," appear on metals when the thickness of the oxide film bears a certain relationship to the wavelength of the incident light. By use of interference colours, therefore, relative thicknesses of oxide films can be compared. By this means, D. J. McAdam, Jr., and G. W. Geil have studied the influence of temperature and film thickness on the rates of oxidation of various steels.

In the July *Journal of Research*, National Bureau of Standards, Washington, the relationship between temperature, time, and film thickness, for each steel, has been represented by one or more views of a three-dimensional diagram. By means of these diagrams, it has been shown that the rate of oxidation varies as a high power (25 to 60) of the absolute temperature. The rate of oxidation, at constant temperature, decreases with increase in film thickness. If, over short intervals, the oxidation time is assumed to vary as a power of the thickness, the exponent decreases with increase in film thickness, from 100 or more to about 2. For constant oxidation time, the thickness increases rapidly with the absolute temperature. If, over short intervals, the thickness is assumed to vary as a power of the absolute temperature, the exponent increases with increase in film thickness, from 1 or less to about 20 or 25. The accelerating influence of temperature on the rate of oxidation thus predominates over the retarding effect of increasing thickness of the film.

By means of the three-dimensional diagrams, comparison is made between steels of various compositions, and a discussion is given of the influence of alloying elements on resistance to oxidation at elevated temperatures.

The rate of oxidation depends on the rate of diffusion of oxygen inward and the rate of diffusion of metal outward, through the oxide film. The rate of diffusion of oxygen, therefore, is proportional to the range of oxygen concentration and to the specific diffusional conductivity of the oxide. The steepness of the gradient of oxygen concentration decreases with increase in film thickness, but the instantaneous rate of oxidation is not inversely proportional to this thickness. The decrease in the rate of oxidation with increase in film thickness is too great to be in accordance with the view that the range of concentration of oxygen and the specific diffusional conductivity are invariant with film thickness. Either the range of oxygen concentration or the specific diffusional conductivity, or both, must be greater for thin than for thick films.

War Supply Areas

A COMMUNICATION issued by the Ministry of Information states that as a further step towards the mobilisation of industrial resources to meet war needs, where these resources are at present "in reserve," the country has been divided into thirteen areas. This arrangement, besides making the main task easier, will ensure that such problems as labour, transport and overlapping are dealt with speedily and in the full knowledge of local conditions. Regional directing organisations are now being set up by the Ministry of Supply and these will take the initiative in establishing suitable "contacts." At the same time they will welcome initiative on the part of others in bringing to them productive capacity, either existing or potential. In order to show the kind of supplies wanted and to guide manufacturers in adapting their resources accordingly, it is proposed to hold exhibitions at key centres where sample articles may be seen and experts consulted. Stress will be laid on the need for machine tools, upon which the country's war production so much depends. By supplying such tools reserve resources can make a contribution of vital importance. Second-hand machine tools which can be rebuilt and reconditioned are urgently needed. Meanwhile, officers of the Ministry of Supply are daily combing the country and surveying plant, floor space, and other essentials to ensure that no productive capacity which can be used or adapted for use in the war effort is neglected. The first demands on "Supply" have been met. The equipment of the Field Force provided has in fact more than satisfied the demands. In addition to what was required for immediate use, great reserves are already available to meet expansions and repair inevitable wastage. While these and other "short term" requirements have been satisfied, the larger task of expanding the mobilisation of the nation's resources for "long-term" prosecution of the war is being energetically tackled. Resources of stocks, plant and skill, not already serving war needs, are being directed to their spheres of greatest usefulness. The smaller industries and firms, traditionally one of the main sources of Britain's industrial strength, are being and will be increasingly called upon. Many firms were unable, owing to the nature of their resources and peace-time demands upon them, immediately to swing over to war production. To an increasing extent since the outbreak of war, resources of this kind are becoming available.

It is pointed out that every individual can co-operate in the war effort by avoiding waste. One form of waste—of which instances have not been lacking—is anything in the nature of a scramble among private individuals to acquire and hoard stocks of materials or manufactured goods. Other examples of waste are mis-direction or overlapping of effort and profiteering. Swiftly and surely the resources of the country are being marshalled and directed to one purpose—the effective prosecution of the war. It is upon Britain's vast reserve strength that the country and its allies may confidently depend for the successful issue of the struggle.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

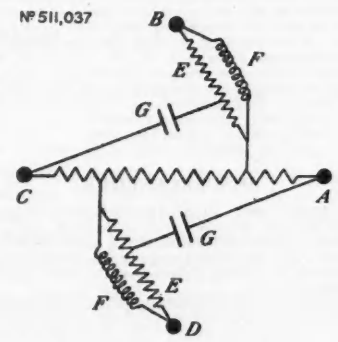
ELECTRICAL APPLIANCES

510,940. *March 22nd*, 1939.—ELECTRIC DISCHARGE TUBES. N. V. Philips' Gloeilampenfabrieken, at Emmasingel, Eindhoven, North-Brabant, Kingdom of the Netherlands.

The invention relates to electric discharge tubes and to a method of manufacturing such tubes. It has previously been proposed to utilise different materials in order to avoid secondary emission during operation of electric discharge tubes and to improve the radiation of heat from different electrodes or other tube components. Thus, for example, it is known to provide the electrodes of discharge tubes, such as grids and anodes, with cooling members and to coat these electrodes, either entirely or partly, with black materials, *e.g.*, carbon or chromium oxide, or materials which have slight secondary emission, *e.g.*, chromium oxide, silver oxide, zirconium or zirconium oxide. According to the invention, in order to reduce secondary emission and to improve the radiation of heat one or more electrodes or other parts of the tube, such as supporting rods, screening members or the tube wall, is or are coated, either entirely or partly, with black titanium oxide; this material may readily be produced by partial reduction of titanium dioxide. It has a very slight secondary emission and owing to its satisfactory radiation it favours considerably the thermal radiation of the bodies on which it is provided. The component so coated may be for example, a grid whose wire-shaped operative portion is coated with the black titanium oxide, or the anode, which is coated, at least on part of its surface, with black titanium oxide. It may be advisable in the latter case to provide the coating both on that side of the anode which is directed towards the cathode (in order to reduce secondary emission), and on the outside of the anode in order to improve thermal radiation. A material advantage of black titanium oxide is that it can be applied very easily to a support by coating the support with titanium dioxide which is then partially reduced. This affords, for example, an advantage with respect to zirconium oxide since titanium dioxide can be reduced more easily than zirconium oxide. It is advantageous to utilise as the support a metal which favours the reduction of the titanium dioxide applied. For this purpose use is preferably made of a metal such as tungsten or molybdenum or, for example, iron, nickel or the like. When these metals are utilised for the support reduction is easily possible by heating in vacuo to a temperature of, say, 1,500 deg. Cent. The use of reducing agents is unnecessary in this case. If other metals are utilised for the support, the titanium dioxide is reduced by heating, for example, in the presence of hydrogen or of mixtures of hydrogen and nitrogen. The titanium dioxide may be applied to the support in many ways; very satisfactory results are obtained if it is applied cataphoretically. —*March 22nd*, 1939.

511,037. *February 7th*, 1938.—BALANCING AND COMPENSATING ARRANGEMENTS FOR TWO-PHASE INSTALLATIONS, Societé Savoisienne de Constructions Electriques.

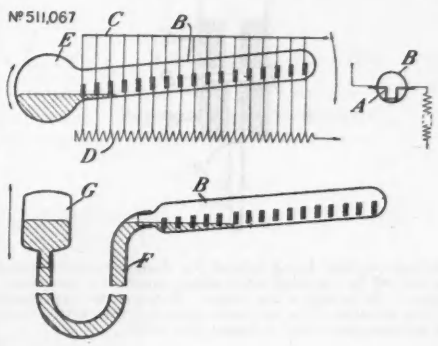
In accordance with this invention a balancing and compensating arrangement for a two-phase installation supplying a single-phase load is characterised by the fact that the single-phase load is connected across two terminals of the two-phase installation and the balancing of the latter is obtained by means of two identical groups of balancing impedances disposed between the two other terminals of the two-phase intallation and the single-phase load. Each group comprises an auto-transformer acting as a balancing inductance or having a balancing inductance mounted in parallel with it. The units so formed are each connected at one end to different terminals of the two-phase installation other than those to which the single-phase load is connected, balancing capacities being connected between different terminals of the installation common to the single-



phase load and suitable points of the auto-transformers. Finally the units consisting of the auto-transformers or the inductances and auto-transformers are connected at the other ends to suitable points of the single-phase load. The diagram shows a balancing arrangement of a two-phase installation, the four terminals of which are represented by A, B, C and D, the installation supplying a single-phase load being diagrammatically represented by the winding AC which is for example the primary winding of the transformer supplying a welding machine. The auto-transformers, inductances and balancing condensers are respectively indicated by E, F and G. The balancing members are connected to the single-phase load at points symmetrical about the centre. The auto-transformer E and the corresponding inductance F may be combined in a single apparatus constituted by a winding disposed on a magnetic circuit provided with air gaps. According to a particular embodiment of the invention the two groups E–F shown may be mounted on a single magnetic core.—*August 8th*, 1939.

511,067. *February 14th*, 1938.—ELECTRIC RESISTANCE SWITCHES, The Walturdaw Cinema Supply Company, Ltd., 46, Gerrard Street, London, W.1, and George Ernest Stubbs, 32, Sundial Avenue, South Norwood, London, S.E.25.

The device described in this specification provides an improved method of obtaining step regulations in resistances, particularly those employed for varying the potential applied to metallic filament, filament lamps. L-shaped contact members A are sealed into the walls of a tube B, the contact members being arranged in pairs. One member of each such pair is connected with lead C while the other members of each such pair are connected with tapping points on the resistance D. The tube is furnished with an enlargement F from which mercury may be displaced in greater or less proportion by varying the inclination of the tube B. In the case of the construction illustrated in the lower drawing, the tube B is connected through a flexible tube F with a reservoir G con-



taining a body of mercury. The tube B in this case is also evacuated and the reservoir G will in use be displaced to such a position that the difference in level of the mercury therein and the mercury in the tube will be substantially 760 m.m., the actual level varying in accordance with the barometric pressure. By raising and lowering the reservoir G the height or level of the mercury in the tube B may be varied.—*August 14th*, 1939.

510,955. *February 10th*, 1938.—DYNAMO-ELECTRIC MACHINES, Robert Bosch G.m.b.H., of 4, Militärstrasse, Stuttgart, Germany.

This invention relates to improvements in control arrangements such as switches and regulators for dynamo-electric machines of the type in which the stator rotates as well as the rotor, and more particularly to motors for adjusting the propellers of aircraft. With electric motors in which the casing may rotate, it is desirable to arrange the control apparatus in the casing, in order to avoid the use of special slip rings, which would be necessary should such machines be mounted on a stationary part of the plant, and separate from the machine. By disposing the apparatus on the rotary member, these will be subject to centrifugal force. In order to reduce these effects, according to the invention the control apparatus is disposed axially of the dynamo-electric machine in such manner that the centre of gravity of the apparatus and particularly of the movable parts of the apparatus lie on the axis of revolution of

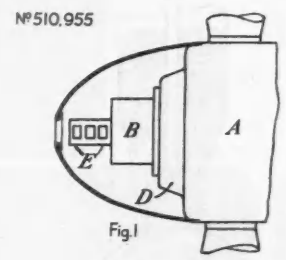


Fig.1

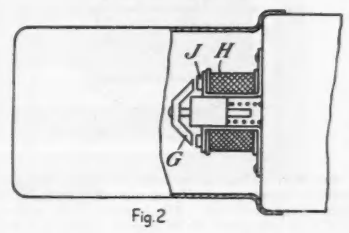


Fig.2

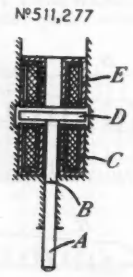
the machine. One form of the construction is shown in Fig. 1. A is the hub of an airscrew mounted on an aircraft. In order to vary the angle of inclination of the propeller blades, an electric motor B and a driving gear D are provided. The driving gear and the motor are disposed on an axial extension of the airscrew. To control the electric motor, electromagnetic switches E and a regulator are provided which are mounted on an axial extension of the electric motor. The switches and regulator are for the purpose of altering the direction of revolution and the speed of revolution of the electric motor, and by this means the adjustment of the propeller blades is effected. The effect of centrifugal force in the control apparatus can also be readily compensated, by so arranging the control apparatus that its movable part, for instance the armature of a switch, is disposed on the axis of revolution of the electric motor and disposed symmetrically to this axis. In Fig. 2 a construction is shown by way of example in which the regulator armature G lies on the extension of the axis and is formed symmetrical to this axis. H is the exciting winding and J the contacts of the switch.—*February 10th*, 1938.

MEASURING & TESTING INSTRUMENTS

511,277. November 12th, 1937.—ELECTRICAL MEASUREMENT OF CHANGES IN PHYSICAL DIMENSIONS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

This invention relates to the electrical measurement of changes in physical dimensions and has reference more particularly to an improved arrangement for electrically measuring changes in dimension, such as changes in length, of the kind comprising an indicating instrument arranged to be responsive to unbalance of a Wheatstone bridge containing inductance coils which are normally fed with alternating current and form part of an induction measuring gauge having a movable armature connected to a movable feeler, the latter having a portion passed interiorly through at least one of the coils. A movable feeler member A having a portion B passed interiorly through a pot magnet C is connected to an armature D. This armature is arranged between the pot magnet C and a superimposed pot magnet E, it being understood that each pot magnet affords an inductance coil which will normally form an element in a Wheatstone bridge and indicating instrument circuit (not shown). When it is desired to locate the work-piece (whose changes in physical dimension are to be detected) under the feeler A without imposing an undue force on the latter, the

uppermost pot magnet E is arranged to be connected over temporarily on to a source of direct current whereby the armature is attracted upwardly and therefore raises the feeler portions B, A as a whole. In order to prevent (during this temporary energisation with direct current) the indicating

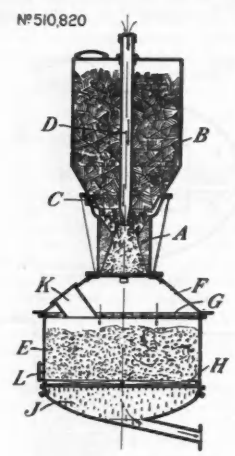


instrument from being injured by flashing over, a suitable switch can be provided which either shunts the instrument or cuts out the voltage of the bridge. Moreover, the upper surface of the armature D is preferably provided with a thin coating of non-magnetic metal.—*August 16th*, 1939.

GAS PRODUCERS

510,820. March 24, 1938. GAS PRODUCERS, Sageb Société Anonyme de Gestion et D'Exploitation de Brevets, 12, rue St.-Pierre, Fribourg, Switzerland.

The gas producer of the invention has a combustion chamber A, in the form of a convergent-divergent, or venturi tube of the primary generator which is fed by a hopper B containing the primary fuel, material capable of furnishing poor gas. Above the venturi tube is an air distributor in the form of a circular crown C provided with perforations so arranged as to direct the air all over the surface of the combustion chamber. According to the invention there is provided in the axis of the primary generator a tuyere D which discharges into the venturi tube, in the vicinity of its throat. The whole thus constitutes an ejector which considerably increases the velocity of the gases and drives them towards the grate forming the bottom of the combustion chamber. In the embodiment shown, the primary generator is mounted above a still, or vessel E, intended to accommodate substances capable of furnishing hydrocarbons on distillation. The vessel is connected with the combustion chamber by a conical member F forming an expansion chamber for the primary gases. A filter G, for example, in the form of a perforated plate, is interposed between the still and the com-



bustion chamber. This filter may be interchangeable and charged with different gas purifying materials at different stages of operation of the producer. The bottom of the still may take the form of a simple grate, or of a grate combined with a preferably interchangeable, filter H, similar to the filter G. Below the still is a receiver J, which collects the distillation products already purified by the overlying filters. The still is charged through an opening K, and the residues are discharged through an outlet L. In operation the ejector constituted by the central tuyere, the venturi tube, and the inlets, sets up a powerful current of air which ensures active combustion and maintains the charge material in a state of incandescence. The gases distilling in the upper part of the combustion chamber and hopper are reduced in passing through the incandescent lower zone and are driven, by the action of the ejector, into the conical chamber, which projects them through the filter, over the entire surface of the granular material contained in the still. In passing through the substances in the vessel E, the gases effect distillation and combine or mingle with the hydrocarbons thus liberated. The liquid and gaseous products generated by the apparatus then enter the receiver, from which they pass into purifiers and separators.—*August 9th*, 1939.

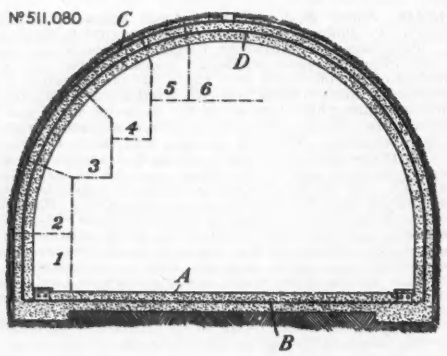
510,861. *March 14th*, 1939.—PROCESS FOR THE PRODUCTION OF COPPER FREE FROM OXYGEN AND OTHER GASES, Heraeus Vacuumschmelze Aktiengesellschaft, Hanau on Main, Germany.

According to the invention, copper which is free from oxygen and is at the same time free or nearly free from other gaseous impurities is produced by first subjecting the copper to an oxidising treatment in the usual manner in a hearth furnace or in a converter. After this the copper is subjected in molten condition to a treatment under reduced pressure in the presence of carbon, for example on a carbon hearth, whereby the copper is degasified and, at the same time, freed from oxygen. If the treatment with carbon is carried out *in vacuo* the carbon monoxide which is formed from the oxygen in the copper with the carbon of the hearth or with any carbon which may have been additionally supplied is continuously pumped off, the result of which is that the copper is freed from oxygen and is degasified much more quickly and completely. The copper which has been treated in the manner described can either be cast *in vacuo* or in a protective atmosphere which prevents the copper from taking up fresh oxygen. As long as all oxidisable impurities are carefully removed by the first furnace refining treatment the product is said to be a copper of very high conductivity, more particularly as any residual small amounts of, for example, bismuth, lead, zinc and similar impurities are reduced in the vacuum in the presence of carbon and distill off. At the same time the figures representing the elongation toughness and impact test of such copper are claimed to be high in the cast form and are still higher, in the product which is rolled or drawn from the ingot.—*August 9th*, 1939.

BUILDING

511,080. *March 28th*, 1939.—THE CONSTRUCTION OF TUNNELS, John Murray, 11, Suffolk Street, Pall Mall, London, S.W.1.

Instead of excavating to an extent to form the entire bore of the tunnel and erecting complete ring sections built up of bolted-together metal troughs, it is proposed in accordance with this invention to excavate the soil in a series of headings 1, 2 . . . 6 of limited size and about 3ft. deep, building up from a concrete foundation. The tunnel is preferably of substantially semi-circular form and the floor is constituted by a monolithic concrete slab A reinforced by one or more steel diaphragms B having dovetailed corrugations into which the concrete enters. Any suitable drainage ducts or conduits are moulded when making the floor. At opposite sides of the flat floor thickened depending footings of concrete are provided to take the load at the foot of the tunnel wall. The outer diaphragm C, the inner



shuttering (not shown) and the reinforcing diaphragm D forming part of the wall structure are erected in sections, the shuttering and the diaphragms of each section being strutted together by suitable means, and the resulting mould cavities provided filled with liquid concrete before the next section is commenced. Liquid concrete is also fed under pressure between the outer corrugated diaphragm and the surrounding subsoil so as to fill in any spaces remaining between them. The reinforcing diaphragm of the floor is preferably joined to the sectional reinforcing diaphragm of the semi-circular tunnel roof and side walls so as to constitute a unitary structure. When the concrete is set the inner shuttering is removed and the operation of erecting and filling repeated in comparatively small sections all around the walls and arch. The soil remaining in the centre part of the tunnel after excavation of the headings is then excavated to a distance of about 3ft. deep, the strata behind being strutted and the process repeated until the tunnel is complete.—*August 14th*, 1939.

METALLURGY

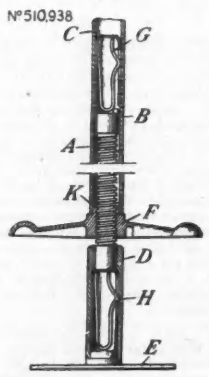
511,513. February 18th, 1938.—PRECIOUS METAL ALLOYS FOR USE AT HIGH TEMPERATURES, Alan Richard Powell and Ernest Robert Box, and Johnson, Matthey and Co., Ltd., all of 78, Hatton Garden, London, E.C.1.

In the manufacture of glass fibres, the molten glass passes through a trough or "bushing" which is electrically heated and provided at the bottom with a number of apertures through which the molten glass flows to produce threads which are then drawn out into fibres. The metal or alloy from which the bushings are made must obviously be capable of resisting high temperatures without oxidation and without developing a coarsely crystalline structure, and also of withstanding the corrosive and erosive action of the molten glass. The object of this invention is to provide an alloy for the construction of bushings which are cheaper and less liable to break down under the action of the large current necessary to provide the desired high temperatures. Parts of apparatus for the production of glass fibres which come into contact with molten glass at high temperatures are constructed of an alloy of platinum or iridio-platinum (containing up to 10 per cent. of iridinum) with from 1 to 10 per cent. of gold. As examples of alloys suitable for the preparation of bushings and the like for the manufacture of glass fibres the following are mentioned (a) 95 per cent. platinum with 5 per cent. of gold, (b) 98 per cent. of platinum and 2 per cent. of gold, and (c) 98 per cent. of iridio-platinum containing 3 per cent of iridium with 2 per cent. of gold. It is stated that in actual working tests when preparing glass fibres with a bushing made from an alloy of the composition (c) above no development of a coarsely crystalline structure adjacent to the electrical terminals is observed, after several weeks continuous operation at about 1400 deg. Cent.—*August 21st*, 1939.

MISCELLANEOUS

510,938. *March 10th*, 1939.—IMPROVEMENTS IN SCAFFOLD JACKS, William Warren Triggs, of Marks & Clerk, 57 & 58, Lincoln's Inn Fields, London, W.C.2, a communication from *Safway Steel Scaffolds Company of America*, 100 *West 10th Street, in the city Wilmington, Delaware, United States of America.*

This invention relates particularly to a scaffold jack adapted

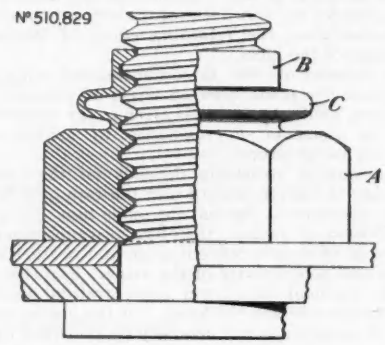


to compensate for variations in elevation of a scaffold foundation. The jack comprises a screw A, over the upper end of which is fixed a sleeve B having a working fit within the post C. On the lower end of the screw is fixed a second sleeve D having substantially the same inside diameter as the post, and engageable over a standard base plate E. A nut F fits on the screw and adjusts the position of the bottom of the post relative to the base plate. The screw fits within the sleeve B and is fixed therein, preferably by welding. A spring retaining member G is positioned within the sleeve, and projects out through a slot in the wall to grip the interior of the post C and prevent accidental disengagement of the jack from the scaffold. The sleeve D has an interior diameter preferably the same as the interior diameter of the post so that it can receive the standard base fitting or a coupling pin and be held in engagement therewith by a spring retaining member H formed in the upstanding pin of the base plate. The nut is formed with an upstanding collar K on the upper end which terminates at its lower end in a shoulder. The collar receives the interior of the post while the shoulder forms a base upon which the post rests. The collar thus co-operates with the sleeve to form a unitary rigid column, and prevents wabbling of the screw within the post. The sleeve and the collar also serve to space the screw from the interior of the post and so prevent damage to the threads. The nut may be provided with handles to facilitate turning and adjusting its position on the screw.—*August 10th*, 1939.

510,829. August 16th, 1938. LOCK-NUTS, Richard Waterman Luce, 460, Beachwood Place, Westfield, State of New Jersey, United States of America.

One example of a lock-nut, made in accordance with this invention, is shown in the accompanying drawing:

The nut is preferably, although not necessarily, made from a single piece of metal and includes the body portion A an internally threaded portion or extension B spaced from one end of the body portion and connected thereto by an intervening axially resilient portion C. The portion B is tapped with the same tap and at the same time as the body, but it is subsequently axially displaced to an extent somewhat greater than the maximum possible axial play between the threads of the nut and any bolt upon which it may be placed, so that the threads of the upper portion are out of phase with the threads of the body. The resilient portion of the nut is such that its internal



diameter is greater than the external diameter of the extension, and the thickness of its wall is substantially uniform and less than the thickness including the threads of any tapped portion of the nut. When the nut is threaded on a bolt, the resilient portion is expanded within the limits of its resiliency and without damage to the threads of either the bolt or nut, by virtue of the out-of-phase relation of the threads. This causes the body to be drawn axially in the direction of the extension and brings the surface of the threads of the body into contact with the threads of the bolt, as shown in the drawing. The threads of the bolt and nut are so maintained in pressure contact by the force exerted by the resilient portion of the nut. A frictional force is thus set up primarily between the surfaces of the threads of the body of the nut and the threads of the bolt that is of sufficient magnitude to resist any movement of the nut on the bolt by virtue of shock or vibration. This force will likewise take up any change in the character of the surfaces either by corrosion or shrinkage.—*August 9th*, 1939.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Railway Club

Thursday, October 5th. Royal Scottish Corporation Hall, Fetter Lane, E.C.4. "The Story of Bradshaw," Canon R. B. Fellows. 7.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

G. A. HARVEY and Co. (LONDON), Ltd., inform us that they are closing their West-end offices at 58, Victoria Street, S.W.1, and transferring the Staff to their Works at Woolwich Road, London, S.E.7.

THE DRAUGHTSMAN PUBLISHING Co., Ltd., publishers of *The Draughtsman*, the Organ of the Association of Engineering and Shipbuilding Draughtsmen, have removed temporarily to 1, Links Road, Epsom, Surrey.

THE CEMENT AND CONCRETE ASSOCIATION has removed its offices to Lincoln Buildings, 15, Turl Street, Oxford. It will continue to act in liaison with the Ballast, Sand, and Allied Trades Association, the Timber Development Association, and other associations engaged in problems concerned with camp buildings, A.R.P., and agriculture.

THE GLACIER METAL COMPANY, Ltd., Alperton, Wembley, Middlesex, informs us that its director Mr. M. Melhuish has voluntarily retired from his position with the Company. The directors wished to retain his services but Mr. Melhuish was unable to alter his decision. Mr. P. J. Flaherty of Johnson Bronze Co., Pennsylvania, U.S.A., has been appointed to the vacancy on the Board.

THE GENERAL ELECTRIC COMPANY, Ltd., wishes to state that the Osram Companies referred to in the published list of enemy concerns are subsidiaries of the Osram G.m.b.H. of Berlin and have no connection of any kind whatsoever, financial or otherwise, with the G.E.C. Osram lamps and valves are made in England entirely out of British and Empire materials. The Osram trade mark for Great Britain and the British Empire is owned exclusively by the G.E.C., which is itself an entirely British Company under British control.